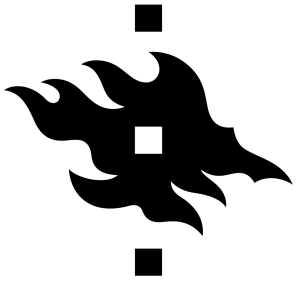

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Impact of ECB's balance sheet policies on heterogeneous firms in Finland: A SVAR analysis with sign and zero restrictions.

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Abstract

The turnover of heterogeneous firms has been shown to behave differently at business cycle frequencies. Traditionally it has been noted that the turnover of small firms is more procyclical. The evidence is however less unambiguous when it comes to more recent business cycle contractions, such as the financial crisis. Majority of the literature considers access to credit to be the driving force behind the differences in cyclicality. Due to asymmetrical information banks intermediating credit consider small firms to be riskier than large. During an economic downturn, safe investments are favored and thus the wedge in access to credit between large and small firms increases. The thesis consequently focuses on the impact of supply of credit on firms. More specifically, the study looks at the responses of firms of different size in Finland to unconventional monetary policy shocks by the European Central Bank (ECB).

Unconventional monetary policy shocks are identified in several ways in the thesis. All approaches are based on a six-variate vector autoregressive (VAR) model. The euro wide variables are the gross domestic product (GDP), consumer prices, ECB's balance sheet, financial stress measured by the Composite Indicator of Systemic Stress (CISS), the spread between the EONIA (Euro OverNight Index Average) and main refinancing operations (MRO) rates and the MRO rate. All variables are provided by either the ECB or Eurostat. The series were aggregated or interpolated to a monthly frequency and seasonally adjusted if needed. The turnover data for Finnish firms is from Statistics Finland. Sales inquiry data collected by Statistics Finland is used as the series for large firms. On the other hand, the series for small firms is based on value added tax data, which covers nearly the entire economy. The turnovers of large and small firms enter the baseline model one at a time. The thesis concentrates on a time period during which the unconventional measures have been in place, that is between January 2010 up until December 2018.

In the thesis, the impact of unconventional monetary policy measures such as the targeted longer-term refinancing operations and the asset purchase programme is studied through the balance sheet of the ECB. Zero and sign restrictions are used to uncover the structural shocks. In the baseline identification, a shock to the central bank's balance sheet is assumed to increase the size of the ECB's balance sheet and decrease financial stress as well as the EONIA-MRO spread for two months. It is additionally assumed that the shock does not have affect GDP, prices and the MRO rate upon impact. The restrictions are implemented through a Bayesian rejection algorithm. The algorithm draws a variance-covariance decomposition from the posterior distribution of the model and checks whether is produces impulse responses that fulfill the restrictions. The results are represented as the median response of the accepted draws.

The results indicate that a shock to the balance sheet of the ECB increases the turnovers of both small and large Finnish firms. The positive impact manifests in two stages; it peaks some three months after the shock for the first time and later again. The impact on small firms is at its highest within 12 months of the innovation. The response of the turnover of large firms is less pronounced directly after the shock but lasts for longer. In summary, the results suggest that the impact is stronger for small firms but more persistent for large. Therefore, the thesis concludes that unconventional monetary policy measures have not benefited small Finnish firms disproportionately.

Keywords
unconventional monetary policy, small firms, SVAR, sign and zero restrictions

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Tiivistelmä

Erikokoisten yritysten liikevaihdon on havaittu reagoivan suhdannekäänteisiin eri tavoin. Perinteisesti kirjallisuudessa on havaittu, että pienten yritysten liikevaihto on suuria yrityksiä myötäsyklisempää. Tuoreempien taantumien, kuten finanssikriisin, kohdalla tulokset ovat tosin olleet vähemmän yksiselitteisiä. Valtaosa kirjallisuudesta pitää rahoituksen saatavuutta suurimpana selittäjänä eroille syklisyydessä. Epäsymmetrisen informaation vuoksi rahoitusta välittävät pankit pitävät pieniä yrityksiä suuria riskialttiimpina. Taantumassa rahoitus suuntautuu entistä vahvemmin vähäriskisiin kohteisiin, eli suuremmille yrityksille. Tästä syystä tutkielmassa tarkastellaan rahoituksen tarjonnan vaikutusta yritystasolla. Kiinnostuksen kohteena on erityisesti Euroopan keskuspankin epätavanomaisten rahapolitiikkashokkien vaikutus erikokoisiin yrityksiin Suomessa.

Tutkielmassa identifioidaan epätavanomaisia rahapolitiikkashokkeja usealla eri tavalla. Kaikkien lähestymistapojen pohjalla on vektoriautoregressiivinen (VAR) malli, jossa muuttujina on bruttokansantuote (BKT), kuluttajahinnat, EKP:n taseen koko, rahoitusmarkkinoiden stressiä kuvaava composite indicator of systemic stress eli CISS-indikaattori, Eoniakoron (euro overnight index average) ja perusrahoitusoperaatioiden koron välinen erotus sekä perusrahoitusoperaatioiden korko. Kaikki muuttujat ovat EKP:n tai Eurostatin tuottamia euroalueen keskiarvoja, jotka on aggregoitu tai interpoloitu kuukausittaisiksi havainnoiksi. Sarjat on lisäksi kausitasoitettu tarvittaessa. Suomalaisten yritysten liikevaihtodata on peräisin Tilastokeskuksesta. Suurten yritysten liikevaihtoa edustaa suurilta yrityksiltä kuukausittain kerättävä myyntiedusteluaineisto. Pienten yritysten data perustuu Verohallinnolta saatavaan oma-aloitteisten verojen aineistoon, joka kattaa lähes koko Suomen yritystoiminnan. Pienten ja suurten yritysten liikevaihtoaineistot lisätään pohjana olevaan malliin yksi kerrallaan. Tutkielmassa tarkastellaan muuttujien välisiä suhteita aikana, jolloin EKP on harjoittanut epätavanomaista rahapolitiikkaa: tammikuusta 2010 joulukuuhun 2018.

Epätavanomaisen rahapolitiikan, kuten pidempiaikaisten rahoitusoperaatioiden ja omaisuuserien osto-ohjelman vaikutusta tutkitaan mallissa EKP:n taseen kautta. Rakenteellisen shokin identifioinnissa käytetään nolla- ja merkkirajoitteita. Keskuspankin taseeseen kohdistuvan shokin oletetaan kasvattavan tasetta, laskevan rahoitusmarkkinoiden stressiä ja painavan Eonia- ja perusrahoitusoperaatioiden korkojen erotusta alas kahden kuukauden ajan. Lisäksi oletetaan, että shokki ei välittömästä vaikuta BKT:hen, euroalueen kuluttajahintoihin tai perusrahoitusoperaatioiden korkoon. Identifiointi perustuu Bayesiläiseen hylkäysalgoritmiin, jossa pohjana olevan mallin posteriorijakaumasta otetaan virheiden varianssi-kovarianssihajotelma ja tarkistetaan, tuottaako se rajoitteiden mukaisen impulssivasteen. Tulokset esitetään hyväksyttyjen otosten mediaanina.

Tutkielmassa osoitetaan, että EKP:n taseeseen kohdistuva shokki kasvattaa pienten ja suurten yritysten liikevaihtoa. Kasvu on kaksivaiheista; se on korkeimmillaan ensimmäisen kerran noin kolme kuukautta shokin jälkeen ja uudestaan myöhemmin. Vaikutus pienten yritysten liikevaihtoon on suurimmillaan vuoden sisällä shokista. Suurten yritysten liikevaihto kasvaa ensimmäisinä kuukausina shokin jälkeen vähemmän suhteessa pieniin, mutta positiivinen vaikutus kestää pidempään. Tiivistettynä epätavanomainen rahapolitiikkashokki vaikuttaa voimakkaammin pieniin yrityksiin, mutta pitkäkestoisemmin suuriin. Pienet yritykset eivät siten hyödy EKP:n epätavanomaisesta rahapolitiikasta yksiselitteisesti enemmän.

Avainsanat
epätavanomainen rahapolitiikka, pienyritykset, SVAR, nolla- ja merkkirajoitteet

Contents

1 Introduction

The asymmetrical performance of firms of different size at business cycle frequencies has been a topic of interest since the seminal work of Bernanke, Gertler, and Gilchrist (1994). Informational asymmetries and the difficulties in obtaining external credit it creates for small firms is established in Fazzari, Hubbard, and Petersen (1987). Fazzari et al. (1987) use data from the manufacturing sector to demonstrate that firms' investment decisions are driven by their cash flow. That is, firms cannot easily substitute internal with external debt and thus they have to adjust their investments instead. Bernanke et al. (1994) build on the established imperfections in the capital market and present a theoretical model where the supply of intermediated credit such as bank loans for small firms depreciates disproportionately compared to large at economic downturns.

Bernanke et al. (1994) suggest that at economic downturns investors channel their money to safe investments. Due to informational asymmetries, more credit is granted to large firms than small and the difference increases along with uncertainty. At economic downturns small firms' demand for credit increases as they strive to keep their operations running through the slump, whereas many large firms have access to internal debt and thus their need for credit is not as acute. The inefficient division of credit can further amplify the initial shock. The theory of Bernanke et al. (1994), known as the *financial accelerator*, thus suggests that small firms suffer disproportionately at times when credit is tight, which can have an adverse impact on the economy as a whole.

As additional evidence, for example Hadlock and Pierce (2010) verify that firm size (coupled with age) is a good predictor of the financial constraint level of the firm. Artola and Genre (2011) use micro level data to show that while majority of European firms perceived to be facing a credit crunch during the 2007–2009 crisis, the firms that actually encountered financial restrictions were young and small. In their seminal paper, Gertler and Gilchrist (1994) show that the disproportional financial constraints of small firms transmit to their turnover. They find that the turnover of small firms with respect to

large in the manufacturing sector declines after periods of tight credit. The results are however less clear when it comes to recessions. Due to the above result, we take the stance of, for example, Abo-Zaid and Zervou (2020). Abo-Zaid and Zervou (2020) assume that monetary policy shocks, rather than the business cycle frequency, are the driving force behind the asymmetries found between heterogeneous firms. We additionally assume that while most of the literature considers periods of *tight* credit, the impact of expansionary monetary policy is likewise asymmetrical in it's impact, only in favor of small firms.

We therefore concentrate on the heterogeneous impact of monetary policy on firms of different size. More specifically, we focus on the monetary policy measures taken by the European Central Bank (ECB)[1] during the last decade. The 2010's have been a period of economic turmoil and sluggish growth. The twin crisis, starting with the global crash of 2007–2009 and followed by the sovereign debt crisis in the euro zone challenged conventional monetary policy. At the beginning of the sovereign debt crisis the key interest rates set by the ECB were already close to zero. Therefore the central bank was compelled to take unforeseen actions in order to boost the economy and restore faith in the euro. These unconventional monetary policy measures have included, among other things, refinancing operations and direct asset purchases. Both measures operate through expanding the balance sheet of the Eurosystem rather than by altering the policy rate. Therefore a specific model for studying the impact of an balance sheet shock is needed to establish their impact.

Our hypothesis is that the unconventional measures have benefited especially credit constrained firms, which, as stated above, tend to be small and medium-sized enterprises (SME). To put it bluntly, our question is: have the ECB's balance sheet policies increased the turnover of smaller firms in Finland disproportionately compared to large? In order to establish a causal relationship, we use a structural vector autoregressive (SVAR) model in line

[1]For convenience, we will use the terms European Central Bank and the Eurosystem interchangeably, while acknowledging the fact that the ECB is only one of the institutions responsible for monetary policy in the euro zone.

with Boeckx, Dossche, and Peersman (2017). We identify a shock to the balance sheet with sign and zero restrictions in a Bayesian manner. The model by Boeckx et al. (2017) is especially tailored for the euro area and for disentangling balance sheet shocks that are orthogonal to other potential forces at play.

The model however identifies the unconventional monetary policy shock through the size of the ECB's balance sheet and therefore excludes responses at the time of announcement of the policy measures. We consider the announcement effects by altering the baseline model in two ways. First, we replace the size of the European Central Bank's balance sheet with the accumulated asset purchase announcements, which are part of the asset purchase programme. This approach builds on, for example, Weale and Wieladek (2016). Second, we identify a shock to the balance sheet based on the rest of the variables in our model, excluding an actual measure for the balance sheet. This alteration rests on Hesse, Hofmann, and Weber (2018) and takes both the refinancing operations as well as the asset purchases into account. We use a time period of 2010M01–2018M12 for the estimation of all of the three approaches; the baseline model as well as the alterations.

The results show that the announcement of an expansionary balance sheet policy measure significantly increases the turnover of large and small Finnish firms within three months of the innovation. The initial impact is, on average, slightly stronger for small firms, for which the peak median response is 0.25%. The response of the turnover of small firms peaks again around seven months after the shock and fades after some 20 months. The second wave of impact is lower and more sluggish for large firms for it peaks around 18 months after the shock. The response of large firm turnover is then again more persistent as it is significant for nearly two and a half years. Therefore the results indicate a stronger, but less persistent impact on the turnover of small Finnish firms.

Our interest in studying the impact on precisely Finnish firms was sparked by the notion made with respect to a business cycle statistic in Finland. Trend Indicator of Output (TIO) is a statistic produced by Statistics Finland. It is the earliest estimate of monthly development of the Finnish economy,

which still builds on actual data from economic agents. The TIO aims at anticipating the trend of the economy nearly in real time. The performance of a statistic can be judged based on the revision from the time the statistic is first published until the last vintage. The mean error of an unbiased statistic should be zero, meaning that once more data is collected, it is equally likely that the figure is revised up or down. That has been more or less the case for the seasonally adjusted month-on-month change of the TIO between 2010 and mid-2014.[2]

On the other hand, from June 2014 up to spring 2020 the 6-month moving average of the revisions has been consistently positive, peaking as high as 0.8 percentage points in the end of 2015. This means that the initial estimate has, on average, severely underestimated the monthly growth for nearly six years and counting. Peltonen (2016) addresses the issue as the senior statistician in charge of the figures. She suggests that the revisions are due to the fact that the figures are based on sales data collected from a sample of large companies and that small firms do better, at least at the time. That leads to the economy-wide output being underestimated.

Our topic is thus interesting from the viewpoint of data quality. Statistical authorities follow a guideline stating that the burden a firm faces when reporting to the authorities should be reasonable compared to the benefit that can be obtained from the information. Based on this trade-off, the general rule stands that the larger the firm, the more in terms of quantity or frequency they have to report. It would additionally be very costly to collect data from a random sample of the whole body of firms in the economy on a monthly basis. The TIO is therefore not the only statistic that rests on data collected from the largest firms.

There are naturally obligations that even the smallest operators cannot escape, such as reporting to tax authorities. The corresponding registry data is however available for other authorities only with a significant lag in Finland and thus cannot be utilized in timely statistics such as the TIO. Asymmetrical behaviour of heterogeneous firms would jeopardize the trustworthiness of the earliest estimates of the state of the economy, which would complicate

[2]http://www.stat.fi/til/ktkk/rev.html

the work of policymakers and other authorities that rely on the data. Therefore understanding the differences in how firms behave has important social benefits. Our work contributes to this knowledge.

The period during which the revisions of the TIO have been consistently positive coincides with expansionary balance sheet policy measures by the European Central Bank. Therefore our aim was to additionally see whether unconventional monetary policy in the euro zone would explain the revisions. The results show that while the impact on turnover of large and small Finnish firms is asymmetrical, it is not unambiguously stronger for small firms. Therefore the source of the revisions of the TIO remains a mystery.

Our work contributes to the existing literature in a number of ways. First, the impact of traditional monetary policy is a well studied topic, but the same can hardly be said about the unconventional measures taken in the aftermath of the crises. A vast majority of the literature on unconventional measures considers areas other than Europe, such as the work on negative interest rates in Japan or quantitative easing in the United States. Therefore our work adds to the scarcer literature concerning policy transmission in the euro area and into heterogeneous firms. We are additionally, to our knowledge, the first ones to study the impact of the unconventional measures on the turnover of firms at the aggregate level. The literature is divided to VAR models considering the impact of the policies on macro variables such as gross domestic product (GDP) or event studies where microeconometric tools are used to uncover the impact on individual firms. We intend to combine these two aspects. We are additionally the first ones to study the impact of balance sheet policies on Finnish firms, due to the fact that the data typically used in event studies in the euro zone is confidential and thus not publicly available for Finland.

The remainder of the study is organized as follows. In the next section, we provide an overview of the unconventional monetary policy measures taken by the European Central Bank. Section three summarizes essential strands of literature and empirical evidence found elsewhere. In the fourth section we presents the structural VAR model as well as the identification strategies we use to disentangle unconventional monetary policy shocks targeted at expanding the balance sheet of the ECB. Section 5 reports and discusses the

results. Finally, section 6 concludes.

2 Unconventional monetary policy measures in Europe

In the aftermath of the sovereign debt crisis the European Central Bank has struggled to reach its mandate of inflation close to (but below) two percent as well as keeping the credit conditions for non-financial corporations and households adequate. Inflation fell from the beginning of 2012, reaching negative values in mid-2015 and again in early 2016. The conventional tool of lowering the policy rates[3] was considered insufficient due to the fact that interest rates were low to begin with. Negative deposit facility rate would mean that banks effectively need to pay for the money they deposit with the Eurosystem, which nudges banks to lend further the money they receive as deposits. In that sense lowering the policy rates below zero should boost the economy similarly to conventional monetary policy. There are however reasons why it might not work as planned.

Banks could be reluctant to pass big negative policy rates onto the deposits of customers in order to avoid losing them. In that case banks are also unable to lower the interest rates on loans they issue any further without making loss in the loan-deposit margin. Banks end up paying the negative rates but there is no impact on the supply of loans or real economy. If banks decide to pass the negative rates forward, the threat of a liquidity trap emerges. Due to the negative rates, household have no incentive to save and thus invest anymore. Instead they begin to hoard money, further deepening the economic slump. The stage at which conventional monetary policy stops working in the way explained above is known as the zero lower bound[4], even though it could be well below zero.

[3]The policy rates are a collection of interest rates that the central bank sets in order to determine their monetary policy stance. For the European Central Bank, these include the rate at which commercial banks can borrow for one week as well as the rate they have to pay in order to deposit money with the Eurosystem.

[4]There is a wide literature surrounding the zero lower bound and it's existence has since been challenged. It nevertheless affected the actions of the ECB after the crises.

Something nevertheless needed to be done to boost inflation. The necessity stemmed from the risk of a deflationary trap. Even modest deflation can cause a harmful situation where households start postponing investments and consumption because they expect prices to drop further in the future. The postponing further diminishes growth making it all the more difficult for the economy to recover. Therefore the Eurosystem took up a number of unconventional monetary policy measures. In June 2014 the Governing Council[5] decided, as the first major central bank, to lower the deposit facility rate below zero. The deposit facility rate reached -0.40% by March 2016 and was lowered again to -0.50% on September 2019. The negative policy rates were combined with refinancing operations, asset purchases and forward guidance, which we'll go through in detail over the next sections.

2.1 Targeted longer-term refinancing operations

The targeted longer-term refinancing operations (TLTROs) provide long-term financing to credit institutions. Their aim is to maintain liquidity in the banking sector and stimulate lending. The operations were introduced in three stages, first TLTRO in June 2014, TLTRO II in March 2016 and TLTRO III in March 2019. Financing from the all of the TLTRO stages is conditional on lending the money to non-financial firms and households. In the first stage the conditionality was issued such that in case of failing to increase their credit supply to the private sector above a certain threshold, the bank in question had to repay the loan. In the second and third stage, the more the participating banks issued loans to private sector, the lower interest rate they faced for their TLTRO borrowings. The interest rates could go as low as to negative rates, creating a strong incentive to banks.

The targeted longer-term refinancing operations are especially targeted at providing additional liquidity for non-financial firms and households. Therefore their significance in easing the credit conditions of SMEs is likely high. Suomen Pankki (2019) asses the performance of the operations. The TLTRO

[5]The Governing Council is the main decision-making body of the ECB. It consists of the Executive Board as well as the heads of the national central banks in the euro zone.

II was very successful in encouraging lending; a total of EUR 739 billion was borrowed by banks under the scheme. According to Suomen Pankki (2019), the banks that participated in the operation also increased corporate lending relative to those who didn't. Then again, there is potential for selection bias and therefore causality cannot be concluded based on quantitative data alone.

2.2 Asset purchase programmes

The European Central Bank additionally started asset purchases in mid-2014. The purchases comprise a set of programmes, each with their own specific targets. These include corporate sector purchase programme (CSPP), public sector purchase programme (PSPP), asset-backed securities purchase programme (ABSPP) and the third covered bond purchase programme (CBPP3). Some purchases are targeted at non-financial firms and households and thus have direct impact on the credit conditions of SMEs. Others only affect SMEs indirectly by increasing the amount of money in the economy. Next we will briefly go through the different programmes.

The asset-backed securities and third covered bond purchase programmes

The asset-backed securities purchase programme started in October 2014. The eligible securities include those secured by for example home loans, car loans, consumer loans and business loans. In addition, they have to have a sufficient credit quality obtained from an external credit assessment institution. There is, on the other hand, no defined minimum or maximum maturity for the securities. From April 2017 onward, the asset-backed securities have been purchased exclusively by six national banks (Bank of Finland is not included in the group) on behalf of the rest.

The third covered bond purchase programme likewise started in October 2014 and is targeted at bonds issued by the banking sector and secured by mortgages or loans to public sector entities. The programme is carried out by many national central banks as well as the ECB. There is similarly no

defined minimum or maximum maturity for the securities. The third covered bond purchase programme covers a large part of total purchases directed at the private sector.

The public sector purchase programme

The public sector purchase programme started in March 2015. Under the programme, the Eurosystem itself purchases bonds issued by regional and local governments as well as recognised agencies and international institutions located in the euro area. By the end of 2018, the Eurosystem had purchased securities from 110 issuers. The national central banks purchase mainly bonds issued by their own government, relative to the size of their government. For 80 percent of the purchases, the risks are carried by the central banks themselves. The purchases were in total over EUR 2,100 billion in March 2020, therefore being by a share of nearly half the largest component of the total assets held by the Eurosystem. The impact of the public sector purchases on SMEs is likely indirect.

The corporate sector purchase programme

The corporate sector purchasing programme started in June 2016. It differs from other other forms of unconventional monetary policy in that it offers direct central bank lending to non-financial corporations. Therefore it impacts real economy without the banking sector serving as a middleman. The programme is carried out by Bank of Finland and five other national central banks acting on behalf of the Eurosystem, coordinated by the ECB. Each central bank is responsible for purchases from issuers in a particular part of the euro area. There is a set of eligibility rules both for the issuer and the debt instruments. The issuers must be non-bank corporations established in the euro area. In some cases also corporations with ultimate parent outside euro area are eligible. The debt instruments, again, have to be issued in the euro zone and denominated in euro. In addition, they have to have a sufficient credit quality obtained from an external credit assessment institution, similarly to the debt instruments accepted for the corporate sector purchase

programme. Lastly, the instrument has to have a remaining maturity of six months to 30 years at the time of purchase. The purchases ended in December 2018 and restarted in November 2019. According to Ertan, Kleymenova, and Tuijn (2020), eligible firms have substituted bank loans for the bond finance offered by the corporate sector purchases. The demand for loans from large firms has increased loans granted for SMEs, meaning that banks have then again substituted large firm loans to SME loans in their portfolios.

2.3 Forward guidance

The central bank combines other monetary policy measures with forward guidance to strengthen the effect of the former. Forward guidance works such that ECB gives a statement that they will, for example, continue asset purchases and keep interest rates low for some period of time into the future. The period can be announced to terminate at a specific date or once a goal, such as target inflation, is met. Banks and households therefore know that the credit conditions won't change in the near future. As a result, banks can set lower interest rates on long-term loans such as mortgages. Forward guidance essentially changes expectations of banks and households, which then determines the interest rates in the long run.

Forward guidance can however also have an adverse impact. It can occur that the central bank has a more negative view on the state of the economy than the general opinion. In that case the announcement of expansionary monetary policy in the future will signal that the economy is doing worse than expected and therefore have a negative impact on investments and other real macroeconomic variables. This phenomena is known as Delphic forward guidance. Campbell, Evans, Fisher, Justiniano, Calomiris, and Woodford (2012) elaborate the topic further.[6]

[6]See also Jarocinski and Karadi (2018).

2.4 Timeline of the combined measures

The asset-backed securities and third covered bond purchase programmes were already in place in 2014, but majority of the combined asset purchases were conducted from 2015 onward. At time when the public sector purchase programme began in March 2015, the ECB's Governing Council set average monthly targets for the purchases. In line with the targets, the net amounts averaged 60 billion euros monthly from March 2015 to March 2016.

In March 2016[7] the ECB announced a new fourfold extension of the unconventional policy measures. First, the monthly net purchases were increased to 80 billion per month for the next 12-month period. Second, the interest rate on the main refinancing operations was lowered by 5 basis points to 0% and the rate on the deposit facility was lowered by 10 basis points to -0.40%. Third, the corporate asset purchase programme began, providing finance directly to non-financial corporations. Lastly, the second set of targeted longer-term refinancing operations was launched. From April 2017 the asset purchase target was set to 60 billion, in January 2018 to 30 billion and finally to 15 billion from October 2018 to December 2018.

On September 12th, 2019 the ECB Governing Council announced additional measures. The rate on the deposit facility was lowered by an additional 10 basis points to -0.50 % and the interest rate on the main refinancing operations was at 0%. The Governing Council stated that they expect the policy rates to remain at their present or lower levels until inflation robustly converges to a level sufficiently close to, but below, 2%. Asset purchases were restarted at a monthly pace of 20 billion euros as from November 2019. The Governing Council expects them too to run for as long as necessary to reinforce the impact of its policy rates. The payments from maturing securities purchased under the programme will be reinvested until the policy rates are raised or beyond that in order to maintain favorable credit conditions. The conditions on the third targeted longer-term refinancing operations were made more advantageous by lowering interest rates and increasing maturity of the loans. As a final step, a part of banks' holdings of excess liquidity will

[7]See ECB (2016) for the March 10, 2016 press release.

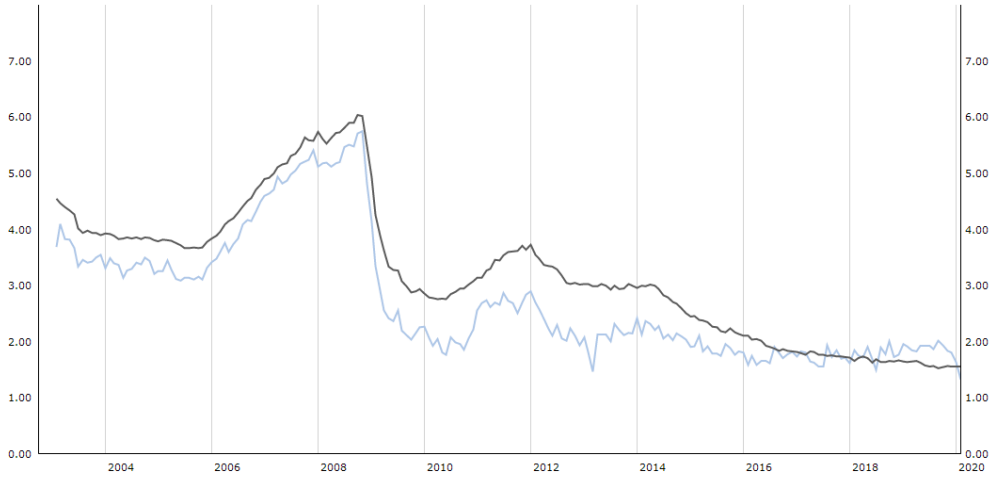

Figure 1: Composite indicator of the cost of borrowing for non-financial enterprises. The pale blue line is an indicator for Finland, whereas the black line represent the euro area average. The figure is taken from the Statistical Data Warehouse.

be exempt from the negative deposit facility rate.[8] The aim of this exemption is to support the banking sector in transmitting monetary policy objectives.

2.5 Empirical evidence

Our assumption is that the measures we went through above eased credit conditions in the Europe and more importantly, in Finland. The composite indicator of the cost of borrowing is based on bank interest rate statistics. It measures the costs of new loans issued for non-financial corporations. Figure 1 shows the indicators for Finland and the euro area for the entire observation period. The series for euro area and Finland behaved somewhat similarly before the 2007–2009 crisis, although the interest rates in Finland have been below the euro area average throughout. After peaking in October 2008 (being 5.74%) the interest rates plummeted by nearly four percentage points by May 2010 (being 1.76%). From there began an increase in costs of borrowing as the Eurosystem drifted into the sovereign debt crisis.

The interest rates have been on a steady decline in the euro zone since

[8]See ECB (2019) for the September, 12 2019 press release.

the beginning of 2014, that is for six years now. A possible explanations for the decline is the grand action taken to boost financial markets after the sovereign debt crisis. The average cost of borrowing for non-financial corporations has declined well over the decline in monetary policy reference rates. Therefore, it is likely that the asset purchases played a significant role. The picture for Finland is not as clear. Non-financial corporations' cost of borrowing has even slightly grown from January 2016 onward after decreasing at a slower pace than the euro zone. It was above the euro area average in July 2016, for the first time since the beginning of the span of the data in 2003. The reason behind this could be that the sovereign debt crisis did not hit Finnish banks particularly hard and therefore some of the measures taken have effectively narrowed the wedge between conditions in healthy and the stressed economies. The interest rates in Finland are nevertheless close to an all-time low and much lower than before the crash of 2008. Evidence on cost of borrowing for non-financial firms after the crises is thus established, but what about the terms?

The euro area bank lending survey offers information on the conditions at which banks lend money. It helps to distinguish supply and demand of credit, which simple measures of the realized lending rates are unable to do. The survey is addressed four times a year to a representative sample of banks operating in the euro area. The survey is divided into three loan categories, where loans to enterprises is listed as one. The participants are asked to describe changes in standards of approving loans, terms and conditions on new loans, factors affecting the supply of loans, loan demand and the share of rejections on a five-point scale. The questions are qualitative and usually formulated as experienced tightening/easing. The survey is commonly used in studying the impact of monetary policy on SMEs, because in the survey, SMEs are separated from the large. Therefore it is possible get evidence on the credit conditions of small and medium-sized firms and compare them to those of large enterprises. The results for Finland are however confidential and therefore the survey does not help us in determining the supply of credit to small and medium-sized enterprises in Finland.

The survey on access to finance of enterprises (SAFE) provides evidence

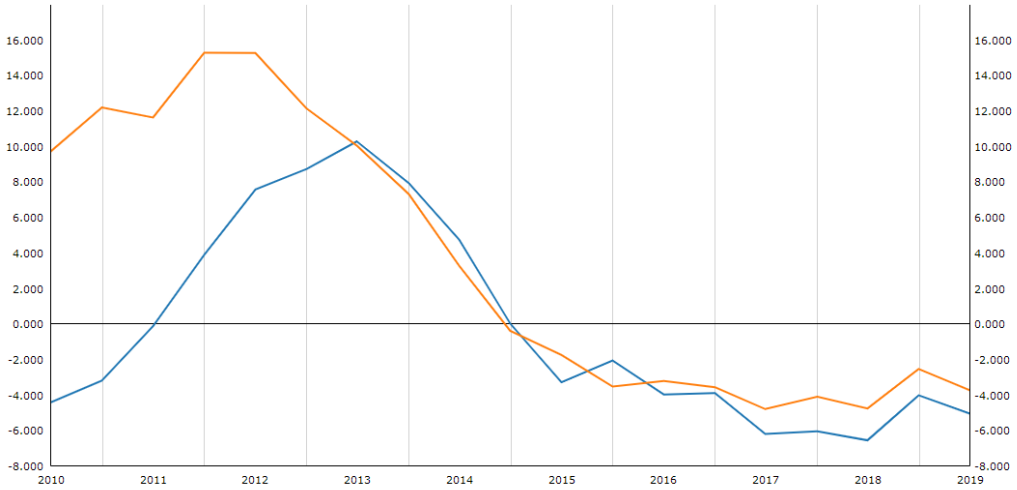

Figure 2: Survey on the access to finance of enterprises: financial gap, small and medium-sized enterprises. The blue line is an indicator for Finland, whereas the orange line represent the euro area average. The figure is taken from the Statistical Data Warehouse.

from the firm side. The sample covers firms of all sizes and across branches of economic activity as well as other dimensions in a balanced manner. Part of the survey is run by the European Central Bank biannually and a more comprehensive selection of questions once a year. Similarly to the bank lending survey, the results are broken down by firm size. The data for Finland is mostly confidential, expect for a measure for experienced financial gap of SMEs. Figure 2 presents the series for Finland and the euro area. The values are positive in case firms perceive that the wedge between their demanded and received credit has widened. Conversely, negative values state that SMEs experienced credit easing compared to the previous period. The beginning of the period is interesting, as there we can see that credit conditions for Finnish SMEs eased while the situation in Europe was on average completely opposite. This difference might be due to differences in the supply or demand side. It could be that in Finland aggregate demand diminished more than supply of credit, and therefore it was easy for firms to get a loan. Another option is that the supply of credit was higher in Finland than in the euro zone on average, possibly due healthier banks. Both series show systematic easing

of credit conditions from the second half of 2014 onward. Therefore we can conclude that for one reason or another, the credit conditions of small and medium-sized firms in Finland eased simultaneously with the unconventional monetary policy measures taken by the European Central Bank.

3 Literature

Our work is related to a compact literature on heterogeneous behaviour of firms of different size at business cycle frequencies. More specifically, most of these papers look at the impact of monetary policy on firms of different size. The literature is concentrated on a period before the introduction of unconventional monetary policy or even the euro zone and therefore we have to look elsewhere in order to study the impact of unconventional monetary policy. The strand of literature focusing on unconventional measures is quite recent and consensus is yet to be found. Therefore we do an overview of the empirical strategies used. A number of papers look at the impact of unconventional monetary policy on SMEs and we naturally go through them in detail. To our knowledge, none however consider the possible asymmetries between the responses of firms of different size to unconventional measures.

3.1 SMEs and the business cycle

There are a number of possible explanations to why small firms might perform differently at business cycle frequencies compared to large. One rather intuitive narrative is that small firms act as subcontractors to larger firms. At downturns the sales of small firms decline more quickly compared to large, because large firms adjust their output first by reducing orders from small firms. In upturns, the sales of small firms with respect to large increase again. Whether the relation would turn to favor small firms depends on if we assume that large firms need to start subcontracting again *before* adjusting their own output.

Another possible explanation is that firms of different size are disproportionately represented in different industries. Thus the differences in cycli-

cality between industries rather than firm size is expected to drive the outcomes. Whether export-driven industries recover more quickly would depend on whether the upturn in national economy is due to improvements in the global state of the economy or domestic demand. The third, and in our mind, the most plausible explanation is asymmetrical access to credit, which impairs small firms especially at economic slumps and benefits them in the recovery periods. We address all these options.

An influential paper by Bernanke et al. (1994) formalizes the theory that small and medium-sized firms perform differently at business cycle frequencies due to asymmetries in access to credit. They introduce the concept of a *financial accelerator*. The term aims at describing a phenomena where a rather small shock can have a large effect on the business cycle. The effect is transmitted through an asymmetrical change in lending in the economy.

Bernanke et al. (1994) suggest that worsening credit conditions caused by an adverse shock hit those with high agency costs more due to *flight to quality*. In other words, at the verge of a recession, investors shift their money away from risky investments into more secure ones. Bernanke et al. (1994) argue that small firms, alongside with consumers, are, on average, the ones who face substantial agency costs of borrowing. This is due to information costs of external finance. There is less information available on small operators and getting access to that information is costly with respect to the amount of debt they demand. This is not the case for listed companies. At an economic downturn, the probability of default increases, which further increases the agency costs of intermediated credit. Large firms face smaller agency costs and thus have better access to external credit but at the same time they have access to more internal debt and thus are less affected by credit tightening to begin with. The worsening of access to credit of small firms at times where they have a higher need for it amplifies the effect of the of the original shock.

The theory by Bernanke et al. (1994) suggests that those with higher agency costs are forced to reduce their output earlier and more than the rest. It also suggests that the same firms would be the first to recover at an economic upturn. Thus the paper lends evidence to a hypothesis that

smaller firms (where firm size is a proxy for credit constrainment) are more procyclical in that they suffer more at economic downturns but on the other hand might recover quicker at upturns.

As empirical evidence in support of the theory of monetary policy shock propagation through credit market asymmetries, a seminal paper by Gertler and Gilchrist (1994) analyzes the responses of small and large manufacturing firms to changes in monetary policy. They use periods of tight credit identified from historical records by Romer and Romer (1989). Gertler and Gilchrist (1994) argue that if credit market frictions play a role, there should be differences in the business cycle behaviour of firms, depending on their access to credit. Difference in access to external finance is hard to measure and therefore Gertler and Gilchrist (1994) use firm size as a proxy in line with Bernanke et al. (1994). They argue that size is an adequate proxy, because size is correlated with the form of external finance the firm primarily uses. Gertler and Gilchrist (1994) show that in their data set, small firms rely more heavily on information-intensive financing, such as bank loans. Additionally, the difference is even more pronounced when it comes to short-term bank loans, the supply of which likely fluctuates with the economy.

For our purposes using size as a proxy is unambiguously a positive thing, as we look at the issue from the viewpoint of data collection. In a way, we need not know whether or not firms on different size perform in a way they do due to financial reasons. We are only interested in the explaining the situation where differences might occur and their magnitude.

Gertler and Gilchrist (1994) study sales as opposed to output due to practical reasons. They use a quarterly data from the manufacturing sector (Quarterly Financial Report for Manufacturing Corporations), which is disaggregated by firm size in terms of gross nominal assets. The size classification is in nominal terms, which, coupled with inflation, introduces bias towards larger firms over time. To overcome the bias, Gertler and Gilchrist (1994) reaggregate the data into two quarterly growth series in terms of another measure of size, sales. The growth rate of small firms considers firms under the thirtieth percentile cutoff each period, whereas the rest are considered large. Ultimately, Gertler and Gilchrist (1994) end up with series for

the growth rates of large and small firms in the manufacturing sector. Their graphical analysis shows that the sales of small firms decline with respect to large firms at times of tight credit and, more often than not, in recessions. However, the pattern in recessions is not very discernible.

Gertler and Gilchrist (1994) estimate a simple vector autoregressive model (VAR) for small and large firms and a dummy for Romer-Romer periods of tights credit. The impulse responses show that a Romer-Romer date has a much larger effect on small firms than large. The difference in the drops of sales is statistically significant after three quarters, peaks at 10 quarters (being 12 %) and persists at around 10 % even after 16 quarters.

Using federal funds rate as a proxy for monetary policy as opposed to the Romer-Romer dates creates insignificant impulse responses. Gertler and Gilchrist (1994) argue that this is due to asymmetry in the monetary policy propagation mechanisms. At bad times, more small firms are effected by credit tightening, because their balance sheets are weak to begin with. The supply of debt for small, credit constrained firms falls consistently when there is a credit tightening, but demand significantly rises only when the economy is in a slump and firms require extra credit to keep their operations running. Romer-Romer dates tend to occur before cyclical downturns, and thus they capture only the intensive, negative effects.

Kudlyak and Sánchez (2017) revisit the work of Gertler and Gilchrist (1994) and extend it to the economic crisis of 2007–2009. Kudlyak and Sánchez (2017) find that after the collapse of Lehman Brothers in September 2008, short-term debt and sales of large firms declined much more than those of small firms, which is highly in contrast with the findings of Gertler and Gilchrist (1994) on the correlation of tight money periods and firm size. Kudlyak and Sánchez (2017) show that their findings are however in line with Gertler and Gilchrist (1994) in small and large firms' behavior during previous recessions (dated by National Bureau of Economic Research NBER). Thus it might be that the period of economic turmoil after the collapse of the Lehman Brothers was primarily not a period of tight credit. It could instead be that other shocks, such as a negative aggregate demand shock due to high level of uncertainty, were more significant in explaining the variance of

macroeconomic variables.

Abo-Zaid and Zervou (2020) build a model that produces outcomes in line with the findings of Kudlyak and Sánchez (2017) as well as those of Gertler and Gilchrist (1994), given that we believe the 2007–2009 crisis not to be a period that is first and foremost characterized by an adverse monetary policy shock. Abo-Zaid and Zervou (2020) aim at explaining difference in the employment behaviour of heterogeneous firms. Abo-Zaid and Zervou (2020) divide firms to two groups; one is dependent on external debt in order to operate and the other one is independent of it. Therefore, the cost of finance drives differences between the two groups. Abo-Zaid and Zervou (2020) deduct that expansionary monetary policy shocks benefit the dependent firms, shifting employment to their end. It is reasonable to think the same is true for output as well. This is in line with the work on periods of tight credit by Gertler and Gilchrist (1994).

Abo-Zaid and Zervou (2020) propose that productivity shocks, on the other hand, benefit independent firms more. The reasoning is that a positive productivity shock improves the performance of all types of firms, but that it also consequently increases interest rate. The increase is an extra cost to the dependent firms and thus in the end they benefit less from the rise in productivity. Following the inference one step further, dependent firms also suffer less from contractionary productivity shocks, because the shock simultaneously lowers the interest rate and thus cost of external finance. The same idea holds for any type of shock that affects aggregate output but doesn't reduce access to credit proportionally. Thus it could be used to explain the better performance of small firms as suggested by Kudlyak and Sánchez (2017). To sum up, the framework by Abo-Zaid and Zervou (2020) suggests, that the type of shock behind a business cycle turn plays a major role in what to expect from the outcome from heterogeneous firms.

Chari, Christiano, and Kehoe (2013) concentrate on the sales of small and large firms at business cycle contractions, and provide empirical evidence in line with the idea that the underlying shock rather than the business cycle turn determines the response of heterogeneous firms. Chari et al. (2013) consider several types of shocks underlying business cycle turns, similarly to

Abo-Zaid and Zervou (2020). Chari et al. (2013) are able to reproduce the results by Gertler and Gilchrist (1994) around tight credit dates. Additionally, they find the difference between sales of large and small firms insignificant after NBER-dated recessions. There are two possible interpretations. First, it could be that small firms react more strongly to monetary policy shocks, as was first pointed out by Gertler and Gilchrist (1994), but that there is no difference when it comes to aggregate shocks that actually cause recessions. Second, it could be that some recessions were mainly caused by monetary policy shocks and the rest by some other type of shock and the different responses by firm size cancel each other out when focusing on recessions. The second explanation is in line with the model by Abo-Zaid and Zervou (2020).

Fort, Haltiwanger, Jarmin, and Miranda (2013) extend the work initiated by Gertler and Gilchrist (1994) and include firm age in their analysis of heterogeneous firms' reaction to business cycles. Firm age is often thought to be an additional proxy for access to credit due to information costs to external credit (see for example Hadlock and Pierce (2010)). Firm age could potentially have additional explanatory power on information asymmetries causing the costs. Bank can have only limited amount of information on the state of a new firm and thus would first cut on these risky loans at times of credit crunch, which is in line with the theory by Bernanke et al. (1994). Fort et al. (2013) find evidence in support of the fact that young firms differ from large in their performance due to restricted access to credit. Thus they contribute to the possible channels in which firm heterogeneity and finance are tied together. As previously stated, we are only interesting in how firm size correlates with financial conditions. Therefore we leave the emphasis on firm age for further research.

Finally, evidence in line with Gertler and Gilchrist (1994) and the financial explanation is again provided by Ehrmann (2005). He studies the sensitivity of small firms to monetary policy shocks. Ehrmann (2005) combines qualitative survey data with macroeconomic analysis. He uses data that includes also the smallest firms with 1-49 employees and observes them at a monthly frequency. The survey consists of questions about the firms perception of the prevalent business conditions as well as demand situation.

Ehrmann (2005) looks at the impact of monetary policy on the survey answers of firms of different size. He includes data from 1981 onward and, in order to avoid a structural break, restricts it to end at the introduction of the euro. The survey data used by Ehrmann (2005) is included in the Ifo Business Climate Index, which is an indicator widely used in German business cycle analysis. This gives credibility to the results.

Ehrmann (2005) uses a structural vector autoregressive model with four variables: growth rate of M3 money, reported business conditions of a size class, three-month money market rate and producer price inflation. Ehrmann (2005) uses producer prices rather than consumer prices for Germany specific reasons. He finds that contractionary monetary policy leads to distributional effects. The shock has a negative impact on the business conditions of firms of all size, but the impact is more pronounced in smaller size classes. The impact increases monotonically when moving from the largest size class to the smallest. The results are however significant only after around 25 months, therefore indicating that the transmission of monetary policy onto the business conditions of firms is a slow process.

Ehrmann (2005) discusses the aforementioned possibility of subcontracting driving the asymmetry. Gertler and Gilchrist (1994) rule out subcontracting by analyzing inventories in addition to sales. Ehrmann (2005) takes a different approach and looks at firms' reported demand status. Subcontracting should be reflected in the demand status of firms. Thus, when controlled for, demand status should take care of the identification. The same strategy holds for industry-specific demand, which could cause bias in the case that small firms were disproportionally represented in more cyclical industries. Controlling for demand effects ensures that the findings are driven by the supply size, that is by the supply of credit.

The results by Ehrmann (2005) can however only be seen as indicative for our purposes, because they are estimated using data from an era before the euro. Additionally, the identified shock is a conventional monetary policy shock, which only impacts the policy rate and the amount of money in the economy. The data Ehrmann (2005) uses is also survey data and therefore discrete. This might complicate the results as a lot of different scenarios can

fit under an answer such as “At present, we consider our business conditions to be i) good”. On the one end there are firms that get by well enough not to experience acute distress about their business conditions. At the other end of the spectrum are start-ups that have experienced skyrocketing growth. Both firms are likely to answer in the same way, as "good" is the most positive option in the survey. Similarly, at economic downturns, the transition down a three-step scale might take a long time and therefore delay the detection of the turn.

We have thus far introduced theory and evidence in favor of financial reasons creating asymmetries in the performance of heterogeneous firms at business cycle frequencies. We briefly present a few papers that support alternative approaches. It is however worth noting that majority of the papers covered so far have controlled for demand effects and thus aren't per se challenged by these alternative views.

An influential paper by Gabaix (2011) introduces reversed causality from firms to the business cycle. He argues that an idiosyncratic, that is, firm specific shock to a large, internationally connected firm can create an aggregate shock that eventually affects the whole business cycle. As such, the work by Gabaix (2011) could be evidence in favor of the hypothesis that the driving force of asymmetrical cyclical behaviour of firms of different size is international connectedness. In Gabaix (2011), large firms operate on more international industries. Then again, the causality runs from large, multinational firms to the business cycle, and therefore does not tell much about the response of small firms.

di Giovanni, Levchenko, and Mejean (2017) introduce further evidence from France. In the footsteps of Gabaix (2011), they study the impact of the 100 largest firms in France on business cycle fluctuation. They propose that the largest firms account for such a major part of the aggregate output in France and are additionally so highly internationally connected that firm specific shocks can affect the business cycle. On the other hand, based on the data used in Cravino and Levchenko (2016), the share of multinational affiliates in total revenue in Finland is among the lowest in Europe (around 18 % compared to approximately 27 % in Sweden and 58 % in the Netherlands).

Therefore international connectedness probably does not play that big of a role in shock transmission in Finland.

Moscarini and Postel-Vinay (2012) in turn study the employment behaviour of large and small firms at business cycle frequencies. Moscarini and Postel-Vinay (2012) find a negative correlation between the job creation rate of large companies and aggregate unemployment. They use data that spans several (including European) countries, multiple sectors and goes back as far as 1978. The corresponding correlation is smaller the smaller the firm (measured in number of employees). The results suggest that large firms' employ more people at times of low unemployment and conversely lay people off when unemployment is above trend. Therefore Moscarini and Postel-Vinay (2012) conclude that large firms are more procyclical in their employment behavior. Fornaro and Luomaranta (2015) use firm-level monthly data from January 1998 to September 2014 to confirm the findings of Moscarini and Postel-Vinay (2012) in Finland for all other sectors except public.

Both the results by Moscarini and Postel-Vinay (2012) and Fornaro and Luomaranta (2015) are somewhat in contrast with those of Gertler and Gilchrist (1994). Neither Moscarini and Postel-Vinay (2012) nor Fornaro and Luomaranta (2015) present any hypotheses on the the driving forces behind the results. They are nevertheless in contrast with the empirical evidence found in relation to financial reasons and therefore can be seen as evidence for alternative explanations for the asymmetry. As Fornaro and Luomaranta (2015) finds the procyclicality of large firm employment to hold on all periods, the results point towards the subcontracting assumption. Then again the work of Moscarini and Postel-Vinay (2012) is set in a different time to Gertler and Gilchrist (1994), and it is possible that the pattern of the economy has fundamentally changed. It could for example be that there are forces at play behind the more current shocks, as was also proposed by Kudlyak and Sánchez (2017). It could also be that employment behaviour differs significantly from that of firms' turnover in terms of timing.

Finally, Fornaro and Luomaranta (2017) present empirical evidence from Finland related to the hypothesis that small firms act as subcontractors to large companies. They study the role of dependencies in productivity of

small and medium enterprises, i.e. does being owned by a mother company affect the productivity of said firms. Fornaro and Luomaranta (2017) make two interesting observations for our purposes. First, the productivity of dependent firms rises when one extends her analysis from micro to small and small and medium-sized enterprises. Second, the dependent to independent employment ratio also rises when moving from the smallest firms to SMEs. Therefore, dependent firms tend to be bigger and the bigger dependent firms tend to be more productive.

It is less than clear whether being owned by a mother company causes a firm to act as a subcontractor. If that was the case however, the analysis of Fornaro and Luomaranta (2017) would suggest that medium-sized rather than small firms act as subcontractors. Therefore subcontracting likely does not explain the good performance of small Finnish firms after the twin crisis.

3.2 Studying the impact of unconventional monetary policy

A key question in studying the impact of a policy is how the impact can be isolated from other forces at play over the same period. When looking at the transmission of monetary policy, one has to be able to separate supply and demand effects. It could be that expansionary monetary policy coincides with rising aggregate demand and therefore an increase in non-financial sector loans or, say, GDP can be explained through demand rather than supply effects. The impact of unconventional monetary policy has mainly been investigated by two approaches: event studies using qualitative micro data or structural vector autoregressions, where the shock is identified either by sign and/or zero restriction or external instruments.

3.2.1 Event studies

Ferrando, Popov, and Udell (2019) study the impact of unconventional monetary policy on SMEs in the euro zone. More specifically, they study the effect of the outright monetary transactions program, that is the purchases of bonds issued by member states, initiated by Mario Draghi's July 2012

declaration to do "whatever it takes" to preserve the euro. More specifically, Ferrando et al. (2019) look at the impact of the declaration itself, as the program was never implemented. The paper uses micro level data from the survey on the access to finance of enterprises, which was introduced in section 2.5. The SAFE data looks at access to credit from the perspective of the firms. Ferrando et al. (2019) find that after the announcement of the program, the credit conditions of small firms improved instantaneously.

Ferrando et al. (2019) aim at identifying the impact of the outright monetary transaction announcement solely on the supply side. Therefore they control for country-sector-time fixed effect, to avoid identifying local demand shocks instead. Ferrando et al. (2019) explain that financial markets reacted to the announcement of the program by lowering interest rates and capital started to flow back to the stressed Southern European countries, even as the ECB did not purchase any bonds through the outright monetary transaction program.

The paper combines the firm-level survey with a data set containing information about bank exposure to sovereign debt and another with bank-firm relationship. As a result they have a data set that is helpful in identifying the entire transmission mechanism of the program, from the impact of the announcement on banks and further how that impact manifests onto firms. Their hypothesis is that the banks that had a larger balance sheet exposure to risky sovereign debt benefited the most from the program. Ferrando et al. (2019) consequently assume that the lending conditions of firms with credit relationship to those banks eased.

Ferrando et al. (2019) create a dummy variable for credit constraint as their main dependent variable. The variable is defined such that it equals one for a firm that has experienced one or more condition for credit constraint in the past six months. It could be that the firm's application for a bank loan was denied or that the firm received less than 75% of the loan amount it requested. Alternatively the firm might have refused a loan offer because the rate was too high or did not apply due to fear of rejection. Based on these qualifications, Ferrando et al. (2019) define 17.9% of the 2,628 firms in the data set to be credit constrained. They use a difference-in-difference

strategy to conclude that the probability that a firm would be credit constrained declined significantly more after the outright monetary transaction announcement for firms borrowing from banks with a significant exposure to risky sovereign debt.

Ferrando et al. (2019) do not find consistent evidence on SMEs improved access to credit having resulted in increased innovation. To our mind, it seems somewhat implausible to assume that firms would, during a financial crisis, grant for a loan in order to push new products into the market. It is more likely that the credit is used to keep operations running at a difficult time. One way would be to use credit to maintain production and accumulate inventory. The idea is to smooth production over fluctuations in aggregate demand, similarly to what was assumed in Gertler and Gilchrist (1994). Ferrando et al. (2019) find that the firms which experienced eased credit conditions increased their cash flow and invested in capital more compared to the rest.

The outright monetary transactions program was a tool that was used in the midst of the sovereign debt crisis. Therefore its main objective was to bring the Eurosystem back from a verge of collapsing rather than to ease credit conditions to boost the economy. It is, in addition, likely that the impact of the program was largest in Southern Europe and Ireland. That is to say, the countries deepest into the crisis benefited the most. We therefore cannot generalize the results found by Ferrando et al. (2019) to hold in the aftermath of the crisis or in Finland. That is especially so since the authors were not able to recover bank-firm relationships in Finland using the aforementioned data sets. The paper nevertheless lends evidence to our hypothesis that unconventional monetary policy can potentially ease credit conditions significantly in the non-financial sector. Additionally, the easing transmits to real variables concerning the firms, though with a significant lag. Ferrando et al. (2019) do not, on the other hand, compare their results on the real effects on SMEs with similar measures on large firms. Therefore we cannot rule out that the results could have been symmetrical among firms of all sizes.

Paludkiewicz (2018) states that unconventional monetary policy mea-

sures seem to have decreased the yields of bonds more than interest rates on new loans issued in Germany. As a result, she studies whether that has encouraged banks to substitute securities for loans to non-financial firms. More specifically, Paludkiewicz (2018) analyzes the impact of ECB's asset purchase programme using a difference-in-difference setup and finds that the banks that see a decline in the yield they receive from securities increase their lending to the non-financial sector more strongly relative to others. That is to say, banks rebalance their portfolios as a response to the monetary policy measures. The effect strengthens when banks face many investment decisions, i.e. when they have many maturing securities in their portfolio.

Paludkiewicz (2018) finds no evidence that the rebalancing would be more pronounced in weakly capitalized banks. This notion is interesting for our purposes. Ferrando et al. (2019) found evidence that the outright monetary transactions program in 2012 eased credit conditions in the countries under most stress during the beginning of the sovereign debt crisis. The banks that were most exposed to the risky sovereign debt before the program were among those who benefited most from it. The evidence found by Paludkiewicz (2018), on the other hand concludes that the asset purchase programme had a symmetrical impact on banks irrespective of their financial situation. It is thus more plausible to assume that the effect found by Paludkiewicz (2018) can be generalized to the Finnish context, unlike those of Ferrando et al. (2019).

Paludkiewicz (2018) assesses the usual problem of separating supply and demand effects by using the heterogeneousness of banks in terms of reinvestment decisions. Banks with more maturing securities were more active in substituting bonds for non-financial loans, which reasserts that the impact is supply-driven. The finding of Paludkiewicz (2018) further strengthens our belief that unconventional monetary policy, in this case the asset purchases, have increased lending to the non-financial sector.

Ertan et al. (2020), on the other hand, study the impact of the corporate sector asset purchase programme. They find that the programme has encouraged large firms to borrow directly from the market instead of banks. Ertan et al. (2020) imply that as large firms can rely more on bond financing due

to the corporate sector purchase programme, their demand for bank loans decreases. That frees up resources in banks that can be used to finance other targets. Ertan et al. (2020) investigate whether small and medium-sized firms provide a natural substitute for the lost large firm debt and therefore focus on the impact of the purchases on small and medium-sized firms.

Ertan et al. (2020) build a similar data set to that of Ferrando et al. (2019) in order to separate the supply effects of the programme from other potential explanations. That is, they use firm-level data on purchases conducted under the corporate sector asset purchase programme and combine it with bank-level data on balance sheet composition. With this combination Ertan et al. (2020) are able to identify the banks that had customers included in the purchases and find that those banks increased loans to SMEs by 12 percent. It could however be that demand effects explain the increased lending and therefore further data is needed to deduct causality. Therefore Ertan et al. (2020) examine the survey on access to credit data on the firms within the affected industry-region cohorts (due to lack of exact firm-level data). They find that the SMEs in those industries and countries that were exposed to corporate sector purchases received more loans conditional on applying them. That is, their application were less often rejected and they more often were granted the full amount they applied for. In addition, the exposed firms paid, on average, lower interest rates.

Ertan et al. (2020) also study the impact on real economy and find that the SMEs that benefited from the programme used the extra credit for investments and hiring additional staff. The results suggest that the increased lending to SMEs has a real impact in that the excess finance is not used for, for example, paying back existing loans. Deducting one step further, we can also think that this might manifest into the macroeconomy, depending on the magnitude of the measures. Ertan et al. (2020) do not, similarly to Ferrando et al. (2019) and Paludkiewicz (2018), compare their results to large firms.

Event studies are an appealing option when one has access to detailed micro data on the behaviour of banks or firms prior to and after the policy change. For example the difference-in-difference strategy can be used to uncover causal relationship from the policy measure onto an economic agent,

given the usual conditions of a credible control group with a parallel pre-event trend and no other events distorting the results. However, an event study is not an option for us. Even though we have access to a mountain of firm-level data about the use of external debt and so forth, we cannot distinguish supply and demand effects from one another based on it. The amount of external debt a firm has does not tell much about how much debt the firms wishes to attain. What we would need is data from surveys such as the bank lending survey or the survey on access to finance of enterprises. Unfortunately, as we went through in section 2.5, the vast majority of data for Finland on both of the surveys is confidential and therefore inaccessible.

3.2.2 Identification with sign and/or zero restrictions

Boeckx et al. (2017) study the impact of an expansion in the European Central Bank's balance sheet. Traditionally monetary policy shocks have been identified through a change in the policy rates. This is natural as conventional monetary policy has mostly consisted of adjusting said rates. The effect of measures that expand the central banks balance sheet is studied less and Boeckx et al. (2017) contribute to that strand of literature. The European Central Bank has introduced many unconventional monetary policy measures that expand their balance sheet, such as the targeted longer-term refinancing operations and asset purchase programmes. Boeckx et al. (2017) however argue that due to anticipation, their model is not suitable for identifying the effects of the asset purchase programs. Therefore they limit their sample to run from from the start of the crisis (and the unconventional measures) in January 2007 until the beginning of the expanded asset purchase program in December 2014.

The anticipation effect can be dealt with by substituting the size of the balance sheet with announcement of purchases that increase the balance sheet. We however note that especially in the case of the targeted longer-term asset purchase programs, majority of the impact likely occurs when the purchases are actually implemented, rather than announced. The reasoning is that as the refinancing operations are conditional on the amount

banks *increase* their lending to the non-financial sector, it is wise to postpone applicable lending until the program is in place. Therefore considering announced accumulation of the balance sheet instead of the actual size might force us to exclude the impact of the refinancing operations.

Boeckx et al. (2017) find results similar to those typically associated with shocks to the interest rate. Expansion in total assets leads to a temporary rise in output and prices in the euro area. Boeckx et al. (2017) further study the transmission mechanisms of the shock by adding a number of financial variables into the SVAR model. They find that a rise in the size of the ECB's balance sheet increases bank lending to both firms and households. The effects on output vary by country. Boeckx et al. (2017) find that output grew least in the countries deepest in the financial countries, such as Greece and Portugal. Health of the banking sector could, according to the authors, play a key role. It is quite intuitive as banks have a large role in the transmission of monetary policy onto the non-financial sector. Finland is likely to be in the group of countries with a better record on solvency given it's healthy banking sector. Thus the bank-lending channel could be stronger in Finland.

Due to the short sample period the authors argue that the results likely cannot be extrapolated to normal times, when the euro area is not under stress. The policy rates set by European Central Bank have then again stayed at or below zero for several years and thus it could be concluded that it is the new normal.[9] In the estimation results of Boeckx et al. (2017), a shock to the balance sheet did create a tightening of the policy rate after a couple of months, stemming from the fact that the central bank adjusted the interest rate at the earlier stages of the sample period. Thus the effect on prices and output of a balance sheet shock should be greater on these more recent times when policy rates have not risen.

Hesse et al. (2018) study the macroeconomic effects of asset purchases using a Bayesian vector autoregressive model. Their focus is on the US and UK and on the question whether the impact of the unconventional measures has diminished over time. Hesse et al. (2018) hypothesize that the effect of

[9]This is especially true as in the time of writing in March 2020 there is again pressure to lower the rates.

monetary policy is likely stronger during times of severe economic distress. That is likely the case for transmission into the credit conditions of SMEs as well. It is therefore interesting to study the impact of unconventional monetary policy from right after the sovereign debt crisis up until now, since the period we are interested in cannot be described as an economic slump. Our work therefore contributes to that of Hesse et al. (2018).

Hesse et al. (2018) use a model with five variables: GDP, CPI, the cumulative sum of asset purchase announcements, the yield on government bonds and the real stock price index. The cumulative asset purchase announcements is what they use as the policy instrument. The model by Hesse et al. (2018) therefore studies the impact of the announcement of the policy rather than the implementation, as Boeckx et al. (2017) did. The results show that the earlier asset purchases in the US and UK had a significant positive impact on real GDP and prices. The later purchases however have not been as efficient in boosting real economy.

The approach of Hesse et al. (2018) could be directly applied to our benchmark model by Boeckx et al. (2017). One would simply need to switch the size of the balance sheet to the cumulative asset purchase announcement. The shock is however identified in Hesse et al. (2018) also by increasing real stock prices and reducing bond yields. In the European context bond yield is likely not a good variable. Stock prices are also hard to include as they would be a collection of values of different countries at potentially very varied economic states. Hesse et al. (2018) use zero restrictions on GDP and prices similarly to Boeckx et al. (2017). The sign restrictions on the bond yield and on stock prices are imposed instantaneously and on the following month, while the sign restrictions for the asset purchase announcement series are imposed on impact and the following five months. The estimation procedure is the same as in Boeckx et al. (2017) where a Bayesian approach with a Normal-Wishart prior is taken.

As a robustness check, Hesse et al. (2018) try an alternative identification procedure in which the shock is restricted based on the financial impact of the balance sheet innovation, but excluding the balance sheet. The identifying restrictions are kept the same. The aim of this approach is to take care of the

anticipation effect. Hesse et al. (2018) infer that the impact of the purchases might diminish over time due to the fact that the market can later anticipate them. Therefore the element of surprise is smaller and some of the impact of the announcement occurs beforehand. This strategy produces results similar to those found with the benchmark model. The authors argue that while ruling out anticipation effects, this strategy mixes the results with those of forward guidance. While Hesse et al. (2018) are interested in especially the impact of asset purchases, we are not as worried in the identifications of two unconventional monetary policy shocks simultaneously.

Weale and Wieladek (2016) also use a Bayesian VAR in order to study the impact of announcements of asset purchases in the United Kingdom and the United States. They use a monthly data that only spans a period when asset purchases were in the repertory of the central banks in question. Weale and Wieladek (2016) use altogether four identification approaches for robustness. These include recursive zero restrictions, pure sign restrictions, combination of zero and sign restrictions and finally, variance decomposition restrictions. Based on eyeballing, all the four procedures seem to identify the same shock. This is interesting, especially as Weale and Wieladek (2016) use an extremely short time period of less than four years. The recursive structure is somewhat an exception, probably due to the fact that it is hardly supported by theory. In contrast to Boeckx et al. (2017) and Hesse et al. (2018), the shock is, in the pure sign restriction approach, identified such that the reactions of GDP and prices are left unrestricted. Weale and Wieladek (2016) follow Uhlig (2005) in using a non-informative Normal-Wishart prior, similarly as was done in Boeckx et al. (2017) and Hesse et al. (2018).

Weale and Wieladek (2016) look at the impact of announced purchases after the active period of the crisis. Therefore their results, although not concerning the euro area, are especially interesting for us. Weale and Wieladek (2016) find that an asset purchase announcement shock worth one percent of GDP leads to a peak impact of 0.62% and 0.25% of GDP in the US and UK, respectively. The impact on prices is similarly stronger in the United States, where it peaks at 0.58% compared to the 0.32% in the UK. Thus the impact of announced asset purchases differs from country to country. The

impacts within the euro system can be expected to be even more heterogeneous, as monetary policy is shared while country-specific qualities are not. A further element of surprise is whether and how the macroeconomic effects are forwarded into firm-level.

Izquierdo, Muñoz, Rubio, and Ulloa (2017) study the impact of a supporting factor introduced with Basel III[10] on Spanish GDP. The transition from Basel II to Basel III was expected to reduce loans to SMEs due to new liquidity ratio requirements. To avoid that from happening, the requirements were augmented with a supporting factor on loans to small and medium-sized enterprises. As a result, banks were allowed to increase their share of 'risky' SME loans and thus continue supplying them. Izquierdo et al. (2017) examine the effect of the supporting factor with a structural vector autoregression model. They use a combination of zero and sign restrictions to to separate the impact of shocks in the credit market from other macroeconomic shocks.

To disentangle supply of credit from demand, the model is identified such that a positive supply shock decreases the banking interest rate spread (difference between the yield of banking bond compared to others of similar maturity) and an innovation in demand in turn increases it. A positive shock in both supply or demand of credit increases the flow of credit. Neither is assumed to have an impact on short-term interest rate of the euro zone GDP. The introduction of the supporting factor is characterized as a credit supply shock. It's impact on the Spanish annual GDP is positive and statistically significant for 2014, and positive but insignificant for 2015 and 2016. The point estimates are 0.28, 0.24 and 0.24, respectively. These results assess the impact of policies targeted directly at increasing lending to small and medium-sized enterprises on the macroeconomy. Izquierdo et al. (2017) however do not study the real impact on the affected firms. Therefore they do not directly lend evidence to our hypothesis that performance of small firms is the driving force of the positive impact on the macroeconomy.

[10]Basel III is an international regulatory contract that introduced a set of improvements to the regulation, supervision and risk management of the banking sector.

3.2.3 Identification with external instruments

Altavilla, Brugnolini, Gürkaynak, Motto, and Ragusa (2019) use factor analysis as they study the effect of unconventional monetary policy through the yield curve. Altavilla et al. (2019) use press release data to identify shocks related to policy target, policy timing, forward guidance and quantitative easing. The paper uses a very small window of 10 minutes to study the impact in order to distinguish the surprises that stem from press releases on one hand and press conferences on the other. According to the strategy of Altavilla et al. (2019), the press release causes a surprise in the target of monetary policy but does not provide other information. The press conference later in the day can cause a timing surprise, where a policy change that was expected to happen in the future ends up happening sooner. In this case, the longer-term expectations stay the same. A forward guidance shock, on the other hand, alters expectations in the longer run. Altavilla et al. (2019) focus on the impact on financial markets. It is plausible to think that monetary policy announcements transmit to the financial sector instantaneously, but a similar effect on the real economy is less likely.

Altavilla et al. (2019) make interesting findings about the impact of different shocks on the yield curve. They show that the target shock has the highest impact on the shortest maturities of the curve and diminishing effect elsewhere. The timing shock similarly has the largest impact on short maturities, but the effect is hump shaped. Forward guidance has a hump shaped impact as well, with most impact on maturities from two up to five years. Finally, quantitative easing mostly affect the longer end of the yield curve. These results show that the unconventional measures taken by the ECB have been complements to each other in that they have impacted the financial (and possibly real) market in different ways.

3.3 Transmission channels of monetary policy

In essence, conventional and unconventional monetary policy affect the economy in the same way. Expansionary monetary policy lowers interest rates, which eases credit conditions, especially for small and medium-sized enter-

prises. That in turn mitigates the impact of flight to quality introduced by Bernanke et al. (1994). Firms respond to lower financial costs by increasing investments. Cheaper loans also decrease the yield of saving with respect to the cost of borrowing for households and make them substitute saving for consuming. Expansionary monetary policy thus boosts private investments in the economy through the interest rate channel.

Expansionary monetary policy also works through the exchange rate channel. Lowered interest rates make the euro area less attractive in terms of investments. The flow of money into Europe drains, which depreciates the currency. The depreciation increases demand from outside the euro zone, therefore boosting exports. When it comes to a single member state, the impact is intensified by increased demand from inside the monetary union as imports become more expensive. The boost in exports stimulates the economies of the member states and further raises demand within the euro zone as well.

Another way in which monetary policy benefits particularly smaller firms is the balance sheet channel. Economic turmoil decreases the value of firms balance sheet. Firms use the size of their balance sheet as collateral, that is to account for the risk banks face when lending. Due to informational asymmetries, smaller firms usually have to provide more collateral and therefore they also benefit more from their balance sheets being appreciated as a result of expansionary monetary policy. Households similarly benefit from the appreciation of the value of their wealth.

The appreciation also enhances further lending through the bank lending channel. The lending ability of banks is tied to the value of their balance sheet through liquidity ratio requirements. Ferrando et al. (2019) find evidence in favor of the outright monetary transaction program impacting the economy through the bank lending channel. The program was successful in lowering the interest rates on government bonds issued by the countries deepest into the sovereign debt crisis. Ferrando et al. (2019) use this information and show that the banks with the highest balance sheet exposure to risky debt before the program increased their lending the most, conditional on the demand. Ferrando et al. (2019) additionally show that the bank lending channel was a

key factor in easing credit conditions for small and medium-sized enterprises. This is natural as smaller firms tend to rely on external debt.

Unconventional monetary policy has some additional transmission channels. One of them is the signalling channel. The European Central Bank showed that they were willing to go the extra mile in order to meet their mandate by introducing the asset purchases and refinancing operations. This coupled up with forward guidance sent a strong signal which has altered market expectations, that is increased them for inflation and lowered for long-term interest rates.

In the portfolio rebalancing channel, the purchases conducted by the central bank alter the spreads between bonds of different maturity. When the European Central Bank buys bonds with a fairly long maturity, it decreases their amount in the economy making them scarcer and thus more expensive. The rise in price consequently decreases expected profits. The short-term bond prices are tied by the zero lower bound and thus the risk premium to fairly long bonds decreases. This in turn guides the investments to bonds with even longer maturity, such as mortgages to households. The asset purchases therefore flatten the yield curve and alter the portfolios of investors in the market. Altavilla et al. (2019) study in detail the exact ways in which monetary policy alters the yield curve.

The work by Paludkiewicz (2018) lends evidence to the portfolio rebalancing channel. She uses a German data set to show that banks affected by the declining yields increased lending to the non-financial sector. The effect was more pronounced the more maturing securities and therefore reinvestment decisions the banks faced. It therefore seems that banks operate on a yield goal and adjust their portfolio as a response to monetary policy measures aimed at altering the yield curve.

The direct pass-through channel means that the unconventional measures have improved credit conditions in the private sector. The targeted longer-term refinancing operations have increased supply of loans, which has increased competition and lowered borrowing costs for non-financial corporations and households. Asset-backed securities and third covered bond purchase programmes have also enhanced loan creation. The purchases have

raised the prices of securities secured by for example house loans and the bonds secured by mortgages and therefore lowered the interest rates paid by households. The increased prices have encouraged banks to create more loans in order to sell them forward, which has improved credit conditions in private non-financial sector.

4 Empirical strategy

4.1 SVAR model of unconventional monetary policy

Our empirical strategy builds on that of Boeckx et al. (2017). Our structural vector autoregressive system can be written as

$$B_0 y_t = B_1 y_{t-1} + \cdots + B_p y_{t-p} + \varepsilon_t. \tag{1}$$

The vector y_t contains the endogenous variables, B_0 is a matrix of the contemporaneous relationships between the variables and B_p is the corresponding coefficient matrix at lag p. The constant term is omitted for convenience. The term ε_t is a vector of serially uncorrelated and homoscedastic structural shocks with zero mean. We additionally assume that

$$\Sigma_\varepsilon = E(\varepsilon_t \varepsilon_t') = I_K. \tag{2}$$

In other words, we assume that the K structural shocks are uncorrelated with one another and normalize the variance of each shock to unity. The endogenous variables are:

$$y_t = \begin{bmatrix} \text{log(seasonally adjusted GDP)} \\ \text{log(seasonally adjusted consumer prices)} \\ \text{log(ECB's total assets)} \\ \text{financial stress indicator CISS} \\ \text{EONIA-MRO spread} \\ \text{MRO rate} \end{bmatrix}.$$

By multiplying both sides of (1) with B_0^{-1} we get:

$$\begin{aligned} B_0^{-1}B_0 y_t &= B_0^{-1}B_1 y_{t-1} + \cdots + B_0^{-1}B_p y_{t-p} + B_0^{-1}\varepsilon_t \\ y_t &= A_1 y_{t-1} + \cdots + A_p y_{t-p} + u_t \text{ or } A(L)y_t = u_t. \end{aligned} \tag{3}$$

Equation (3) is the reduced form representation of equation (1), where $A_1 = B_0^{-1}B_1$ and $u_t = B_0^{-1}\varepsilon_t$. The latter part of equation (3) uses lag polynomial notation. The reduced-form equation can be estimated by standard methods, such as ordinary least squares. The reduced-form innovations u_t are linear combinations of the structural residuals ε_t and therefore serially uncorrelated and exogenous. However, the variance-covariance matrix Σ_u is not diagonal and thus we cannot directly interpret the shocks. Using the fact that $u_t = B_0^{-1}\varepsilon_t$, and standard matrix calculus rules, the variance-covariance matrix of u_t takes the form

$$\begin{aligned} \Sigma_u &= E(u_t u_t') \\ &= E(B_0^{-1}\varepsilon_t (B_0^{-1}\varepsilon_t)') \\ &= E(B_0^{-1}\varepsilon_t \varepsilon_t' B_0^{-1\prime}). \end{aligned}$$

The matrix B_0^{-1} is non-stochastic and therefore we can take it out of the expectation operation. We can further use the property in (2) to derive

$$\begin{aligned} \Sigma_u &= B_0^{-1}E(\varepsilon_t \varepsilon_t')B_0^{-1\prime} \\ &= B_0^{-1}B_0^{-1\prime}. \end{aligned} \tag{4}$$

Σ_u has $K(K+1)/2$ parameters free for estimation, where K is again the number of shocks in the system. B_0^{-1}, on the other hand, has K^2 parameters. Therefore we would need $K^2 - K(K+1)/2 = K(K-1)/2$ restrictions to uniquely identify the relationship between the structural and reduced form errors B_0^{-1} and consequently recover the structural shocks ε_t. Traditionally, this would be done with for example recursive short-run restriction with a Choleski decomposition or long-run restrictions. In the case of identification through sign restrictions we instead impose restrictions on the responses to

a shock.

4.2 Identification of a balance sheet shock

The impulse responses can be recovered by looking at the moving average representations of equation (3):

$$\begin{aligned} y_t &= A(L)^{-1} u_t \\ &= \sum_{i=0}^{\infty} \phi_i u_{t-i} \\ &= \sum_{i=0}^{\infty} \phi_i B_0^{-1} \varepsilon_{t-i} \qquad (5) \\ &= \sum_{i=0}^{\infty} \psi_i \varepsilon_{t-i}. \qquad (6) \end{aligned}$$

The term ϕ_i represents the responses to the reduced-form shocks u_t at horizon i. The responses follow a recursive structure:

$$\begin{aligned} \phi_0 &= I_K \\ \phi_1 &= \phi_0 A_1 \\ &\vdots \\ \phi_i &= \sum_{j=1}^{i} \phi_{i-j} A_j, \qquad (7) \end{aligned}$$

where the A_j are from the reduced-form system in (3). In case the vector autoregression is for the differences, the impulse responses for the levels can be obtained by accumulation. Response for the levels at horizon i is thus the sum of the responses $\phi_{o\ldots i}$ for the differences. The term ψ_i in equation (6), again, captures the responses of the endogenous variables to a structural shock. In identification through sign restrictions, we consequently restrict the signs of the responses stored in ψ_i.

In practise, the estimation is done with the MATLAB package ZeroSignVAR. The following description of the estimation algorithm is based on Breitenlechner, Geiger, and Sindermann (2018).

1. Estimate the parameters $\hat{A}_{1\dots p}$ and $\hat{\Sigma}_u$ of the reduced-form system in equation (3) using ordinary least squares.

2. Use the estimates $\hat{A}_{1\dots p}$ and $\hat{\Sigma}_u$ as location parameters for a Normal-Inverse-Wishart prior to obtain the same reduced-form parameters from the posterior.[11]

3. Assume that equation (4) is a Choleski decomposition, i.e. $\Sigma_u = PP\prime$ in order to extract the orthogonal innovations from the model in step 2. The Choleski decomposition is used for practical reasons as $\varepsilon_t = P^{-1}u_t$ fulfills the condition in equation (2):

$$\begin{aligned}\Sigma_\varepsilon &= E(P^{-1}u_t u_t' P^{-1\prime}) \\ &= P^{-1}\Sigma_u P^{-1\prime} \\ &= P^{-1}PP'P^{-1\prime} \\ &= I_K.\end{aligned}$$

4. Use the estimated lower triangular Choleski factor P, $\hat{A}_{1\dots p}$ and $\hat{\Sigma}_u$ to obtain candidate responses to the structural shocks $\psi_i = \phi_i P$ according to equation (5). Recall that the reduced-form responses are determined recursively according to equation (7).

5. Multiply the candidate responses from step 4 with a random orthonormal and recursive matrix Q, which satisfies $Q'Q = I$. This step creates an alternative candidate response to the structural shocks. The recursive structure of the matrix ensures that the responses are zero when needed.

6. Check whether the impulse responses fulfill the imposed sign and zero restrictions. If they do, the responses bear a structural interpretation and are kept. If not, they are discarded.

[11] Normal-Inverse-Wishart is a natural conjugate and therefore the posterior takes the same form.

7. Repeat steps 5–6 for as many times as you want the number of subdraws to be.

8. Repeat steps 2–6 for as many times as you wish the number of model draws to be.

A few points need clarifying. The Choleski decomposition is only used for orthogonalization, not for identification. The identification is based purely on the sign and zero restrictions we impose. The final number of candidate draws is the model draws multiplied by the subdraws. The number of successful draws on the other hand depends on the tightness of the identification strategy. The estimation procedure produces a set of models that each fulfill the restriction and are consistent with the data. Therefore identification through sign restrictions yields set identification, which has to be kept in mind when interpreting the results. In our case, the results represent median responses among the satisfactory models. As opposed to for example recursive identification, we additionally only restrict the responses to our shock of interest. Thus it is important that we present a credible narrative on how the unconventional monetary policy shock can be separated from the rest $K - 1$ shocks. Next we'll go through our identifying assumptions, which follow Boeckx et al. (2017).

A shock to central bank's balance sheet has to be separated from policy changes that result endogenously from, say, financial stress or consumer prices. This is necessary in order to draw conclusions about causality. Without a surprise element, it could as well be that a change in financial stress that the ECB acts upon drives changes in real economy rather than the policy measure. Output and prices are included in the model to account for the macroeconomic developments that might impact the European Central Bank's decisions. The CISS indicator of financial stress is included to capture endogenous responses to financial instability. Boeckx et al. (2017) show that the change in the ECB's balance sheet is closely related to the CISS indicator. They further indicate that only around 25 percent of the forecast error variance decomposition of ECB's balance sheet is driven by exogenous shocks, which makes it all the more important to identify the exogenous

shocks correctly.

Table 1: Identification of a shock to the central bank's balance sheet

GDP	CPI	ECB's total assets	CISS	EONIA-MRO spread	MRO
0	0	+	-	-	0

In order to uncover exogenous innovations, the responses to a structural unconventional monetary policy shock are restricted according to table 1. Following Boeckx et al. (2017), it is assumed that the balance sheet shock does not affect output and consumer prices contemporaneously, that is directly after the shock. This assumption builds on the idea of sticky prices and lagged impact of monetary policy on real variables. Real shocks such as aggregate supply and demand affect output and consumer prices instantaneously. We can therefore separate real shocks from the balance sheet shock based on the first two restrictions in 1.

We naturally expect the size of the European Central Bank's balance sheet to increase in response to an expansionary shock to the balance sheet. Next, we coincide with the original paper in expecting the monetary policy shock not to increase financial stress. This condition separates the impact from a policy measure to financial stress from the reverse endogenous mechanism of how monetary policy is determined. It therefore takes care of reversed causality. Third, we assume that the identified shock does not increase the EONIA-MRO spread. If the spread were to rise, it would likely be the result of a increased demand for credit rather than supply.

Finally, our goal is to look at the impact of an expansion of the balance sheet, given a certain policy rate. Therefore we restrict the contemporaneous impact on the main refinancing rate to be zero. All three zero restrictions hold only upon impact, whereas we impose the sign restrictions to hold instantaneously as well as the next period. We, in line with Boeckx et al. (2017), believe that these restrictions are adequate in identifying the shock to the balance sheet orthogonal to all other possible shocks in the system. That is, we trust that our identification has at least one restriction that separates the unconventional monetary policy shock from all others, but most

Table 2: Identification of an asset purchase announcement shock

GDP	CPI	announced purchases	CISS	EONIA-MRO spread	MRO
0	0	+	-	-	0

importantly, demand shocks.

4.3 Alternative identification approaches

As mentioned above, Boeckx et al. (2017) predict that due to anticipation, their model is not suitable for identifying the effects of the asset purchase programs. The purchases are announced in advance, which could cause that the financial as well as the real market variables react before any purchases are conducted. Our identification strategy for the balance sheet shock assumes that the size of the balance sheet increases, and thus all reactions before the balance sheet actually expands are excluded. We address this issue by altering our baseline model in two ways: by substituting the size of the balance sheet by announced purchases and by excluding the measure for the balance sheet altogether.

In the announced purchases option we follow Weale and Wieladek (2016). Similar approach was considered in one of the model specifications in Hesse et al. (2018). By substituting the size of the balance sheet with announced purchases, we naturally look at the impact of the announcement of asset purchases, at the time of the announcement. Thus we disregard the impact of the amount of purchases the central bank actually performs and look at the signalling effect of monetary policy rather than, say, direct pass-through. In addition, this approach is only helpful when studying the impact of the asset purchase programme. We leave targeted longer-term refinancing operations out because they do not encourage banks to increase lending to the non-financial sector before the operations are actually implemented. Therefore we construct a series of the European Central Bank's accumulated announced asset purchases based on the timeline explained in section 2.4, but correct them for the time of announcement from press releases by the central bank. We thereby identify an asset purchase shock, which should however pro-

Table 3: Identification of a balance sheet shock excluding ECB total assets

GDP	CPI	CISS	EONIA-MRO spread	MRO
0	0	-	-	0

duce parallel results to combined unconventional monetary policies targeted at expanding the balance sheet. The identifying assumptions for the asset purchase shock are summarized in table 2.

In our second approach we exclude total assets as was done in Hesse et al. (2018). In this setting we identify a shock to the balance sheet based on the rest of the variables in our baseline model. In essence, we claim that a point in time where GDP, consumer prices and the main refinancing operations rate do not change while financial stress and the EONIA-MRO spread decrease can only occur due to a shock to the balance sheet. This way we are able to catch the impact of expansion of the European Central Bank's balance sheet, regardless of whether the effect occurs upon announcement of implementation. On the upside, when using the exclusion approach, we do not need to discriminate between asset purchases and targeted longer-term refinancing operations. Therefore any difference between the responses to a balance sheet shock identified with or without the European Central Bank's total assets should be driven by the announcement effects. The identifying assumptions for the balance sheet shock excluding ECB total assets are summarized in table 3.

Both of our alterations above build on the baseline model and identification strategy of Boeckx et al. (2017). It pays off to consider the plausibility of the identifying assumptions on other dimensions other than the anticipation effect. For this purpose we consider the analysis of Puonti (2019).

Puonti (2019) studies the validity of the sign restriction imposed in Boeckx et al. (2017). Puonti (2019) uses statistical identification in her approach and thus doesn't have to impose neither zero nor sign restrictions on the variables in order to identify the shock of interest. The methodology is helpful because it allows one to compare the impulse responses of the restricted variables to those in a model where restriction were not made. Puonti (2019) considers

the same time period as was done in Boeckx et al. (2017) and confirms that the restrictions used are sensible, except for the zero restriction on GDP. Puonti (2019) finds that when the instantaneous impact of the shock on GDP is not restricted to zero, the response actually peaks on impact. For that reason we consider altering the above identification strategies so that we restrict the impact on GDP to be non-negative.

The estimation procedure used by Boeckx et al. (2017) is founded in the seminal work of Uhlig (2005) on identification via sign restrictions. The pure sign restriction approach used in Uhlig (2005) has received critique for potentially identifying multiple shocks simultaneously.[12] Lanne and Luoto (2020) confirm that the model by Uhlig (2005) identifies two shocks instead of one, the other shock being a money demand shock. For this reason, we assume, more recent takes on models of monetary policy combine sign with zero restrictions. In case of Boeckx et al. (2017), the zero restrictions on GDP and prices are used to disentangle a shock to the ECB's balance sheet from aggregate demand and supply shocks.

Uhlig (2017) discusses the evolution of monetary policy models that use sign restrictions. While acknowledging that the sign restrictions in Uhlig (2005) identify two shocks simultaneously, he does not see zero restrictions as an improvement in many cases. He brings up the widely used assumption of sticky prices in monetary shock studies as an example.[13] The assumption of truly non-existent instantaneous impact of a monetary policy shock to prices does not seem to be credible in reality, as some prices always react. Therefore inclusion of zero restrictions is not a quick fix, but rather a shift from potentially misidentifying the monetary policy shock to imposing a restriction that is implausible with equal probability.

With this discussion we consider easing the zero restrictions on prices as well as GDP. This should be quite sensible as the analysis of Lanne and Luoto (2020) considers the exact identification of Uhlig (2005) and therefore is not directly related to our model. In our model specification we assume that

[12]This possibility was brought up by Uhlig (2005) himself.

[13]Our model utilizes the same sticky price assumption when imposing a zero restriction on consumer prices.

the negative sign restriction on the EONIA-MRO spread disentangles money demand shocks from our policy shock of interest. In addition, Boeckx et al. (2017) argue that easing the restriction on output and prices can potentially cause us to confuse our monetary policy shock with one in the real economy such as aggregate demand. The monetary policy shock we are interested in is however distinguished from supply and demand shocks also by the assumption that supply and demand shocks do not affect asset purchases. The narrative behind the assumption is that, at the time of the announcement, officials do not know about the current GDP and prices and therefore cannot endogenously react to them. We are therefore convinced that easing the restrictions on GDP and prices does not confuse the balance sheet shock with others and consider this option as well when we report the results.

4.4 Data

We use the same variables as in Boeckx et al. (2017) in the baseline, six-variate model. All of the variables are euro area wide. GDP and the consumer price index (CPI) represent the impact on the real economy. Financial stress is measured by the ECB's composite indicator of systemic stress (CISS) introduced by Holló, Kremer, and Lo Duca (2012). The euro overnight index average (EONIA) stands for the rate at which bank provides loans for each other with a maturity of one day. The main refinancing operations (MRO) rate is then again the rate banks pay when they borrow from the central bank with a maturity of one week. The EONIA-MRO spread consequently measures the difference of those rates and gives insight to liquidity in the economy. The spread increases at times of tight credit and conversely decreases with excess liquidity.

Unless stated otherwise, all of the data is taken from the ECB Statistical Data Warehouse and either interpolated in R or aggregated in SAS, in order to reach a monthly frequency. The data for EONIA and MRO rates is available on a daily frequency. We first calculated the daily spread between the two rates and then aggregated it to a monthly frequency by taking an average of the daily observations. The CISS indicator was calculated by taking

an average from weekly observations. Total assets of the ECB were likewise available on a weekly basis and transformed to a monthly series by taking the last observation of the month as a closing stock.

We use the harmonized consumer index (HCPI) as the measure for consumer prices. The data is provided by Eurostat[14] at a monthly frequency. The consumer price index uses 2015 as the base year. Preliminary check revealed seasonality in the data. We therefore seasonally adjusted it with JDemetra+, a software specifically developed for seasonal adjustment. The software uses an algorithm called TRAMO/SEATS when dealing with the data. The procedure decomposes the data into seasonal, trend and irregular components and then removes the seasonal part. As of February 2015, Eurostat and the European Central Bank suggest that all seasonal adjustment of official statistics be done with JDemetra+.

The data for real GDP is likewise an index, which uses 2015 as the base year. In addition, the data is seasonally and calendar adjusted by the ECB. GDP is however only available at a quarterly frequency. Therefore we followed the example of Boeckx et al. (2017) and constructed a monthly series with Chow-Lin interpolation procedure. The interpolation uses industrial production as the indicator series, that is in creating the artificial monthly variation.[15] We are interested in the post-crisis period and therefore limit our data to run from 2010 onward. We follow the literature in estimating our model in (log) levels.[16] Based on descriptive analysis we include trend as well as a constant term in our reduced-form VAR. The model is trend-stationary, that is, after including the trend term the characteristic roots lie within unit circle.

We augment the model explained above with data from Finland to study the impact of unconventional monetary policy on Finnish firms of different size. Since our assumption is that small firms benefit from easing credit conditions, we study their response separately. We are additionally interested in finding possible asymmetries between size groups. To study this, we consider

[14]Eurostat is the statistical office of the European Union.

[15]The interpolation was executed with the tempdisagg package available in R.

[16]For example Boeckx et al. (2017), Hesse et al. (2018) and Weale and Wieladek (2016) all use levels in their estimation.

the responses of large firms to a balance sheet shock and compare the results to those from small firms.

The thesis is written on the premises of Statistics Finland, which grants us access to a wide variety of firm-level data. The Trend Indicator of Output is primarily based on a monthly survey data Statistics Finland collects from large firms. The sales inquiry covers altogether 2000 companies that are considered most significant per number of employees and/or turnover. The sample is however balanced such that all industries are included. It covers around 70 % of total sales and 0.1 to 5.9 percent of the number of firms per industry in Finland. The sample is not static. Instead, the sample is revised on a monthly basis in case of corporate acquisitions. Firms with declining turnovers are replaced with ones that have increased their sales once a year. Small firms are underrepresented in the survey by default. The composition of the firms makes it infeasible to rely on the survey data alone in studying the differences of small and large firms. Even if one were to exclude the largest firms from the data set, the remaining set of enterprises would unlikely be a unbiased sample of small firms. The remaining data would cover only the largest fraction of the body of firms we wish to study. Therefore additional data is needed.

On top of the survey Statistics Finland collects themselves, they have micro data on all the firms in the economy, based on tax returns on value-added tax. The data is collected on three different frequencies depending on firm size. The group of firms with a yearly turnover worth less than 30,000 euros file the return yearly. Those with a turnover between 30,000 and 100,000 file it quarterly and the largest firms monthly. Luckily, even the last group includes firms that are reasonably small and thus we can limit our focus on it.

We construct the data for Finland by combining information from two sources, the sales inquiry and the tax figures. We use the sales inquiry data as the series for large firms as opposed to constructing one from scratch with the value-added tax data. The reason is that we are interested in seeing whether a shock to the balance sheet distorts the Trend Indicator of Output through source data. Best way to do so is to use the actual data set the indicator

uses in our analysis as well. We then exclude the firms included in the sales inquiry each month from the tax data. From the remaining body of firms we isolate those that are regarded as small by EU standards.[17] We focus on the turnover of small firms as opposed to micro firms due to the fact that small firms are more homogeneous. Micro firms include both self-employed people as well as startups and therefore we expect the data for micro firms to be noisy. In summary, our series for large firms is based on the sales inquiry, whereas the data for small comes from tax data. As our variables of interest we use series for both the turnover of large and small firms.

Firm size is determined based on the financial statement provided at the end of the year. Multinational firms pose additional complexity into the picture, as their headcount and turnover have to be partitioned among the countries they operate in. Therefore the size classification for the data for 2019 is not ready at the time of writing in March 2020, and we have no choice but to exclude 2019 from our estimations. It is problematic that ultimately our data covers the period 2010M01–2018M12, which is only 108 data points per series. This can consequently affect the sharpness of our results. The same issue was however present in the work by Boeckx et al. (2017) and even more so in Weale and Wieladek (2016). Short timelines are therefore usual in the relevant literature, which is natural as unconventional measures have not been in use for long.

The turnover data for large and small firms enter the model separately. If it were the case that the euro area GDP is an accurate indicator of Finnish turnover data, we would have exact multicollinearity and the model would not be valid. Following Rieth, Piffer, and Hachula (2016)[18], we however assume that data from a single member state is not a proxy for GDP. Both the series for small and large firms contained seasonality, which was dealt with using the TRAMO/SEATS algorithm. Both variables additionally enter the model in logs.

[17] Small firms are defined in the EU as having a staff headcount between 10 and 50 employees or alternatively an annual turnover of more than two but less than 10 million euros.

[18] Rieth et al. (2016) study the impact of unconventional monetary policy on macroeconomy in Germany.

We are convinced that our choice of frequency and identification serve the purpose of our study. Event studies employing high frequency data are probably well suited for uncovering the transmission of monetary policy to the financial sector. Then again, the impact on macroeconomic variables presumably does not emerge within days, or even more so, hours of the announcement of the policy. Joyce, Miles, Scott, and Vayanos (2012) verifies the reasoning that event studies are not suitable for finding macroeconomic impacts. Therefore our SVAR model of unconventional monetary policy with a monthly frequency is reasonable. We however take possible anticipation effect into consideration with robustness checks.

5 Results

In this section we'll go through the results from our estimations. Our model is the six-variate model of unconventional monetary policy introduced by Boeckx et al. (2017), augmented with Finnish turnover data. We study the impact on large and small firms separately. We identify a shock to the European Central Bank's balance sheet using sign and zero restrictions identically to what was done in Boeckx et al. (2017). We considered several alterations to the identification strategy in section 4.3 and, for robustness, report the results from these exercises as well.

We consider a sample period of 2010:M1–2018:M12 throughout. The Schwarz lag length selection criteria suggests using one lag. We consider such a short lag order to conflict with existing literature too much and therefore use three lags similarly to Boeckx et al. (2017). All of the impulse responses are a result of the Bayesian estimation procedure explained in section 4.2. The figures represent the median response among all of the models that produced impulse responses that fulfilled our imposed restriction. We consider responses where zero is not included in two thirds of the posterior distribution (the darker gray area in the subsequent figures), to be significant. The responses of the variables in logs can be read as percentages. We compare results obtained by different identification procedures and finish with a discussion.

5.1 Balance sheet shock with ECB total assets

Figures 3 and 4 represents the results for our baseline model. In this identification strategy, an unconventional monetary policy shock is characterized by an increase in ECB's total assets, which persists for about three months before fading out to trend. The shock instantaneously increases GDP. The impact stays significant for a few months and finally declines to negative, but insignificant figures after 20 periods. The impact on prices becomes positive instantly after the zero restriction quits binding. The positive response persists for some 45 months but is significant for only a handful of periods midway. The balance sheet shock significantly decreases financial stress for 5 months following the innovation. The downward pressure on the EONIA-MRO spread stays significant for a few months after the shock. The impact on the main refinancing operation rate is significantly positive from 7–14 months after the shock, which is somewhat surprising as the rate has been raised on only two occasions during our sample period.

In figure 3, our variable of interest is the turnover of small firms. The response is significant only at lag seven, where it is between 0.1 and 0.3 percent. The positive impact fades to trend after 20 months. In figure 4, we again look at the impact on the largest firms in Finland. The response is positive and significant at one or two periods around 15 months after the shock. The impact for large firms is however more modest as it peaks between 0.01 and 0.15 percent. Therefore the impact on firms of different size is not entirely symmetrical. Small firms respond stronger and earlier, but the impact on large firms is more persistent. Thus heterogeneous firms in Finland respond to an unconventional monetary policy shock identified with the size of the European Central Bank's balance sheet differently, but very modestly so. We'll go through the results from our alternative identification methods before discussing the validity of this result.

5.2 Asset purchase announcement shock

We move on to consider the possible announcement effects. We assess them by replacing the size of the balance sheet with a series of the European

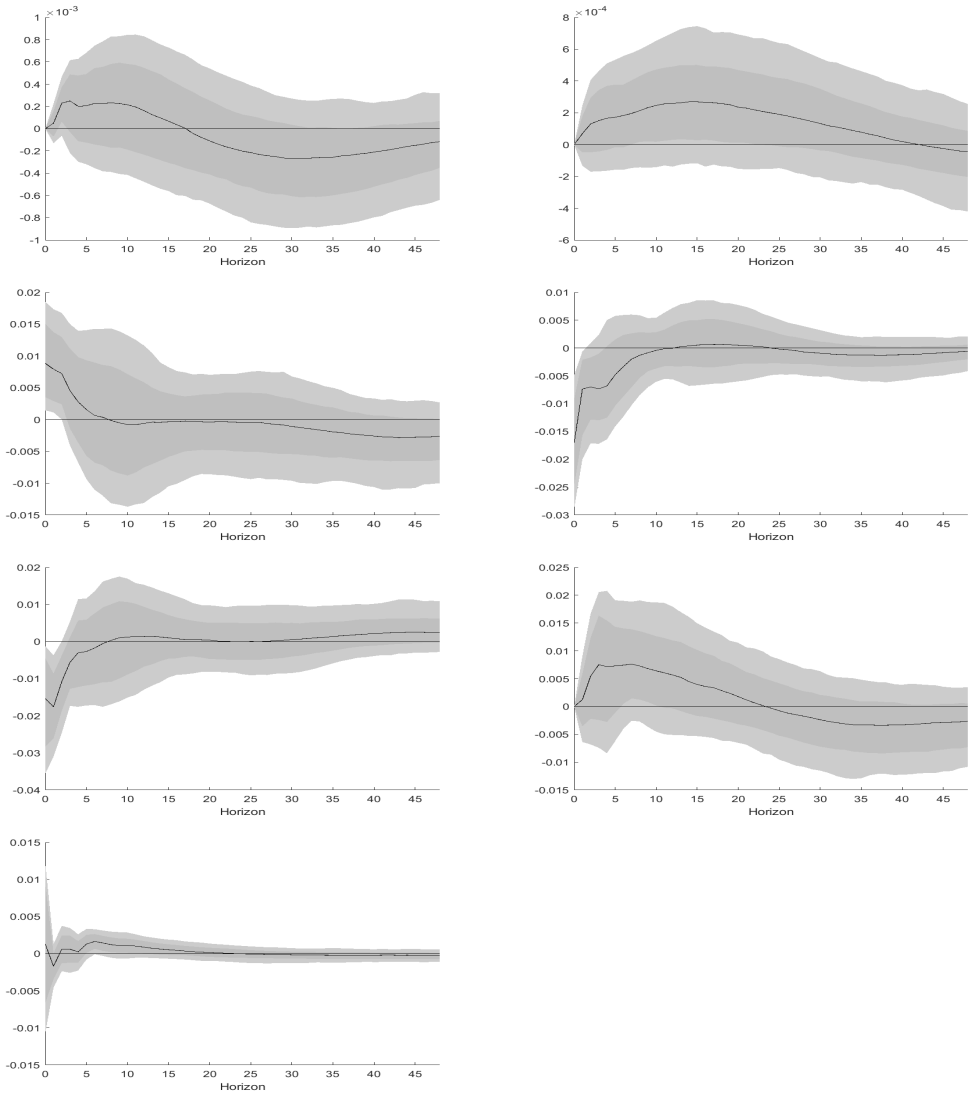

Figure 3: The impact of a balance sheet shock on small firms. The order of the variables from left to right, top to bottom is GDP, CPI, ECB total assets, CISS, EONIA-MRO spread, MRO rate and the turnover of small firms. The impulse responses of GDP, CPI and MRO rate are restricted to being zero upon impact. The response of ECB total assets is assumed non-negative. Conversely, the responses of financial stress and the EONIA-MRO spread are assumed non-positive. The sign restrictions are in place for two periods. The turnover of small firms is left unrestricted. The figures show median responses with the light and dark gray areas representing 90% and two thirds of the identified posterior distribution, respectively.

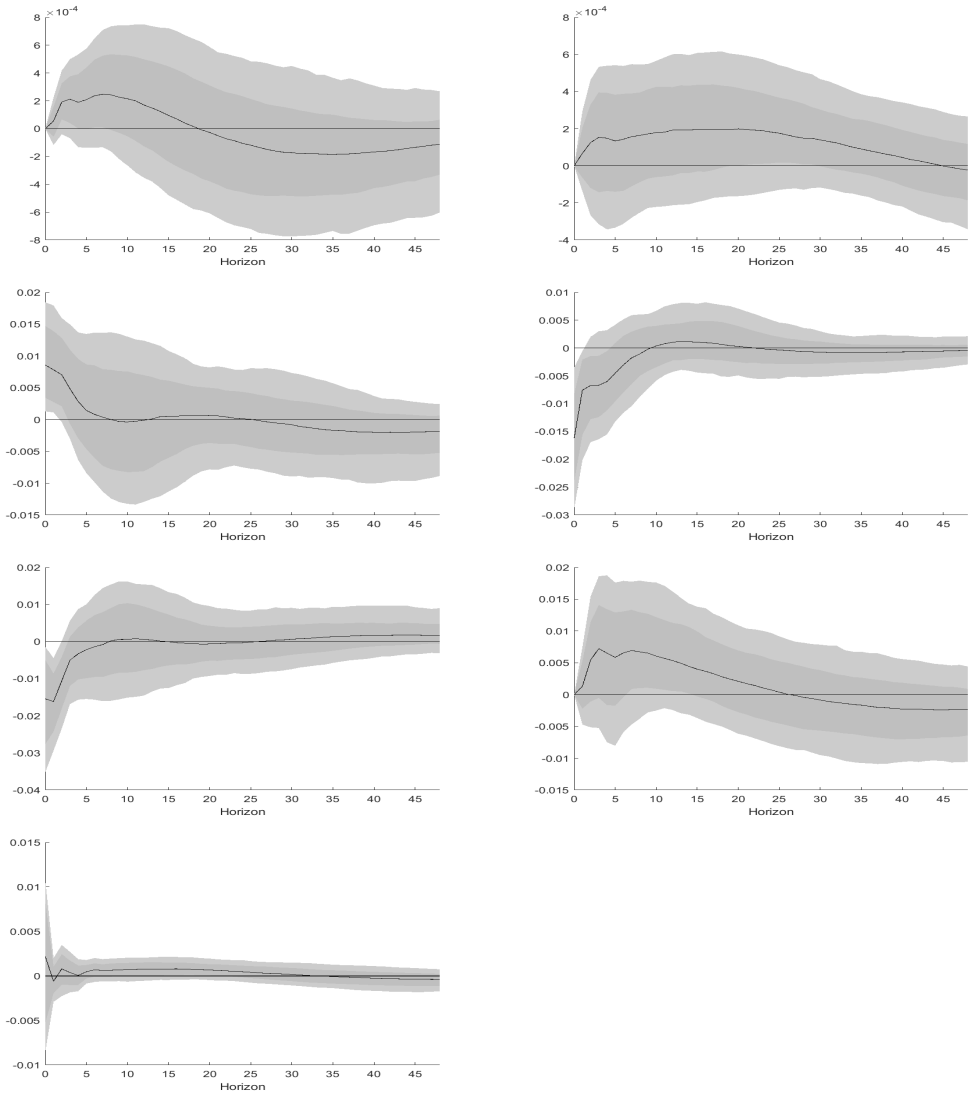

Figure 4: The impact of a balance sheet shock on large firms. The order of the variables from left to right, top to bottom is GDP, CPI, ECB total assets, CISS, EONIA-MRO spread, MRO rate and the turnover of large firms. The impulse responses of GDP, CPI and MRO rate are restricted to being zero upon impact. The response of ECB total assets is assumed non-negative. Conversely, the responses of financial stress and the EONIA-MRO spread are assumed non-positive. The sign restrictions are in place for two periods. The turnover of large firms is left unrestricted. The figures show median responses with the light and dark gray areas representing 90% and two thirds of the identified posterior distribution, respectively.

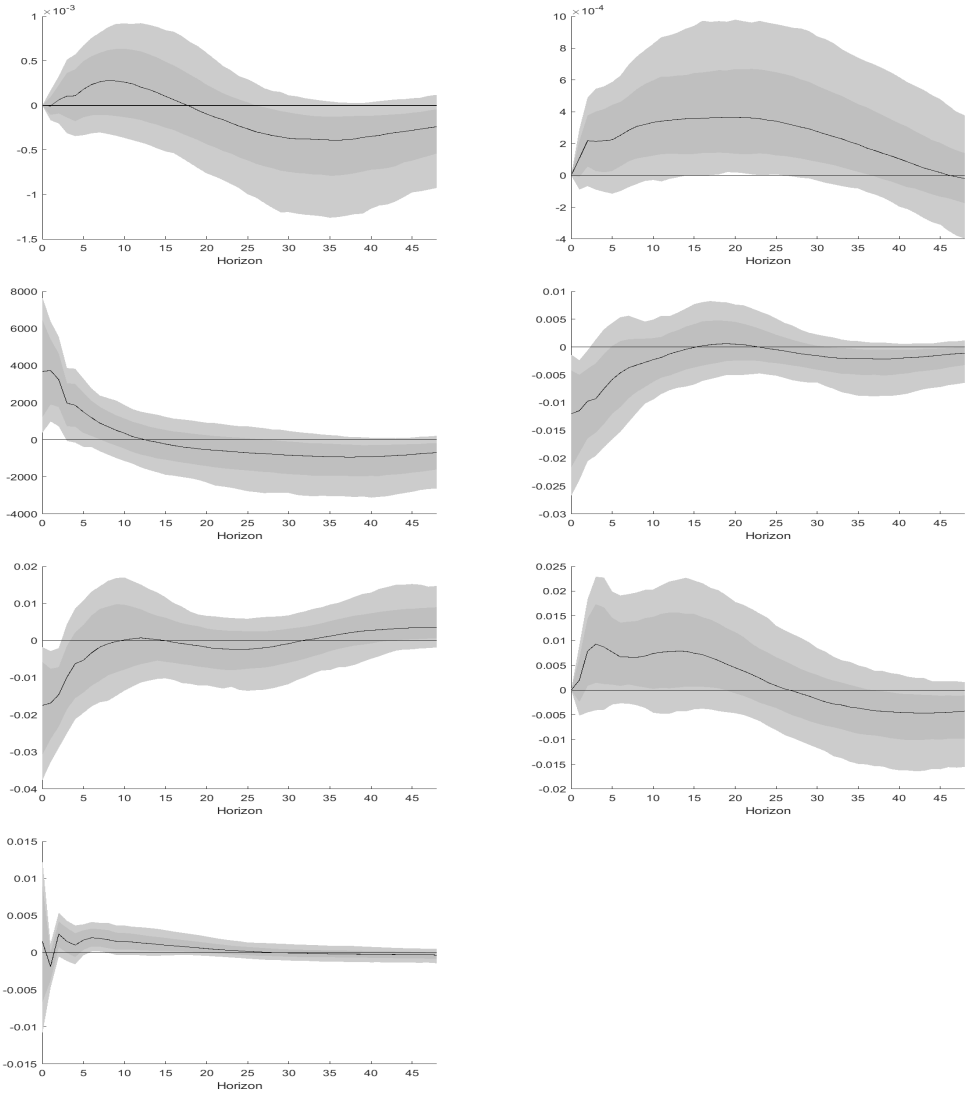

Figure 5: The impact of an asset purchase announcement shock on small firms. The order of the variables from left to right, top to bottom is GDP, CPI, ECB's announced asset purchases, CISS, EONIA-MRO spread, MRO rate and the turnover of small firms. The impulse responses of GDP, CPI and MRO rate are restricted to being zero upon impact. The response of ECB's announced asset purchases is assumed non-negative. Conversely, the responses of financial stress and the EONIA-MRO spread are assumed non-positive. The sign restrictions are in place for two periods. The turnover of small firms is left unrestricted. The figures show median responses with the light and dark gray areas representing 90% and two thirds of the identified posterior distribution, respectively.

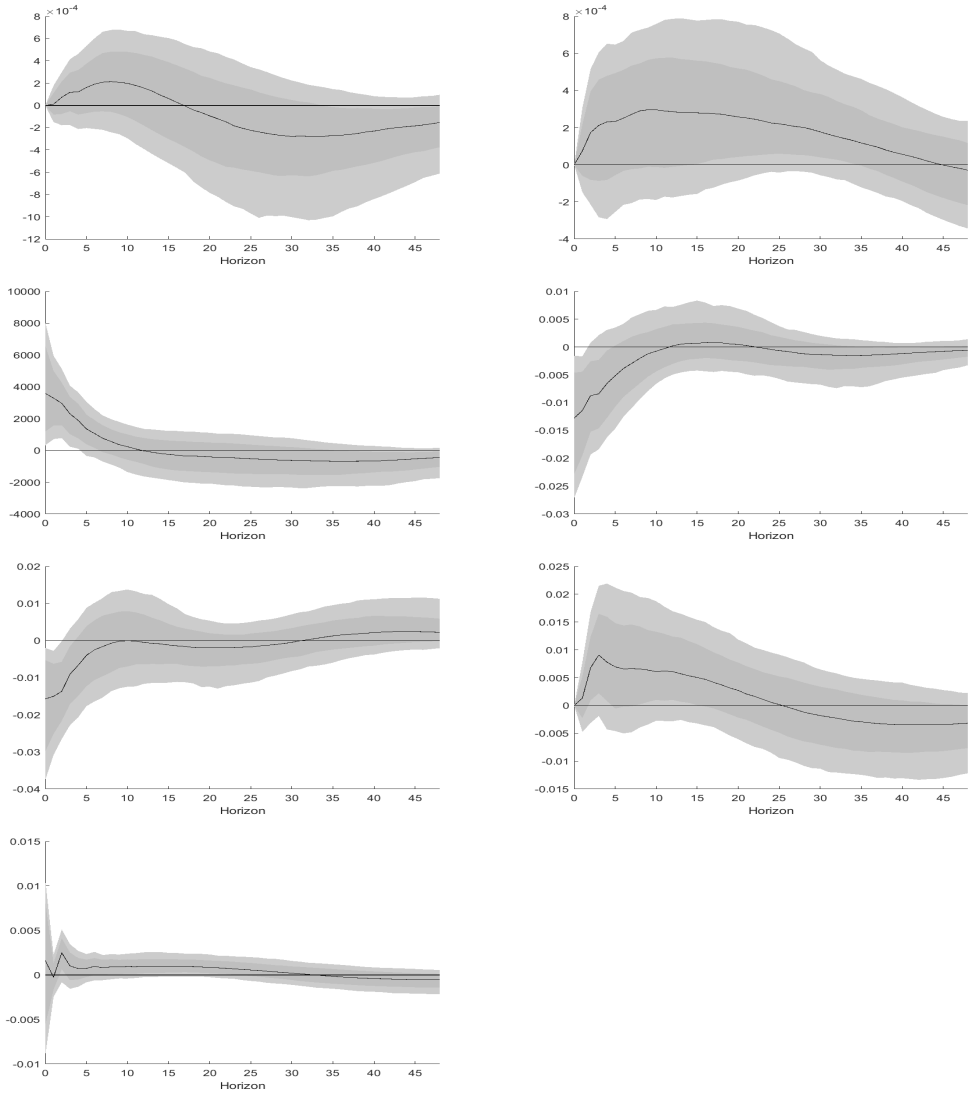

Figure 6: The impact of an asset purchase announcement shock on large firms. The order of the variables from left to right, top to bottom is GDP, CPI, ECB's announced asset purchases, CISS, EONIA-MRO spread, MRO rate and the turnover of large firms. The impulse responses of GDP, CPI and MRO rate are restricted to being zero upon impact. The response of ECB's announced asset purchases is assumed non-negative. Conversely, the responses of financial stress and the EONIA-MRO spread are assumed non-positive. The sign restrictions are in place for two periods. The turnover of large firms is left unrestricted. The figures show median responses with the light and dark gray areas representing 90% and two thirds of the identified posterior distribution, respectively.

Central Bank's announced asset purchases in the baseline model by Boeckx et al. (2017). Therefore we identify an asset purchase announcement shock, which differs from the baseline shock such that it covers anticipation effects, but excludes targeted longer-term refinancing operations. The responses can be seen from figures 5 and 6. The announcement shock is characterized by a rise in announced purchases, which lasts for some six months before fading out.

The impact on GDP is less pronounced than in the case of a balance sheet shock. The positive early impact is insignificant and the response even becomes significantly negative after around 27 months. The impact on prices is then again bigger and significant for years, especially in the model with small firms. The announcement shock furthermore decreases financial stress significantly for some five months in figures 5 and 6. The impact fades at a slower pace than in the case of a balance sheet shock. The impact on financial stress additionally fluctuates between positive and negative. This pattern was not as visible in figures 3 and 4, which suggests that the two specifications do not catch exactly the same shock. The same fluctuating pattern can be seen on the impact on the EONIA-MRO spread. The impact of the main refinancing operations rate is quite the same. The positive impact must, again, be driven by the beginning of the time series as the rate has not been risen towards the end of the decade.

Our variable of interest in figure 5 is again the turnover of small firms. The impact of the announcement shock on small firms is bigger and more persistent than it was with the balance sheet shock. The positive impact peaks at lag three, where it is between 0.1 and 0.4 percent. The median response is once more significant and around 0.2 percent after five and up until 18 months. Figure 6 contains the response of the turnover of large firms. The impulse responses between the two size groups are fairly similar. The main difference is that, after the simultaneous peak at lag three, the response is significant again after 12 and up until 20 months. On top of being more sluggish, the latter response is also lower for the large firms, that is the median is around 0.1 percent.

The responses to a balance sheet shock and an announcement shock have

interesting differences. The response of GDP to an asset purchase announcement shock is less significant, whereas the opposite is true for prices. The response of both turnovers peak almost instantaneously, which was not visible in figures 3 and 4. Therefore it seems that as assumed in Boeckx et al. (2017), the baseline model is not able to catch the early responses to a policy measure targeted at expanding the balance sheet of the European Central Bank. It could on the other hand be that the differences are driven by the fact that the announcement shock specified here excludes targeted longer-term refinancing operations. We therefore consider an alternative approach to including the announcement effects, in which the refinancing operations are not excluded.

5.3 Balance sheet shock excluding ECB total assets

We proceed onto our second exercise with the aim to find out whether anticipation effects play a role in the transmission of unconventional monetary policy in the euro area. We consider the approach of Hesse et al. (2018) and simply exclude total assets of the central bank from the vector autoregression. The identification otherwise follows that of Boeckx et al. (2017). The advantage of this approach is that is does not discriminate between different unconventional monetary policy measures, as long as they affect the other variables in the model identically. Thus we assume to find combined results for the asset purchase programme as well as targeted longer-term refinancing operations.

Figures 7 and 8 show the impulse responses to a balance sheet shock identified without the central bank's total assets. The results closely resemble those found as a response to an asset purchase announcement shock in figures 5 and 6. Therefore it seems that the (assumed) inclusion of the targeted longer-term refinancing operations does not drastically change the picture. Most significant difference can be found in the response of GDP. In the estimation including large firms, it is significant for a few periods, as was in the baseline approach in figure 4. The difference is nevertheless small and cannot be seen in the model including turnover of small firms. Thus the

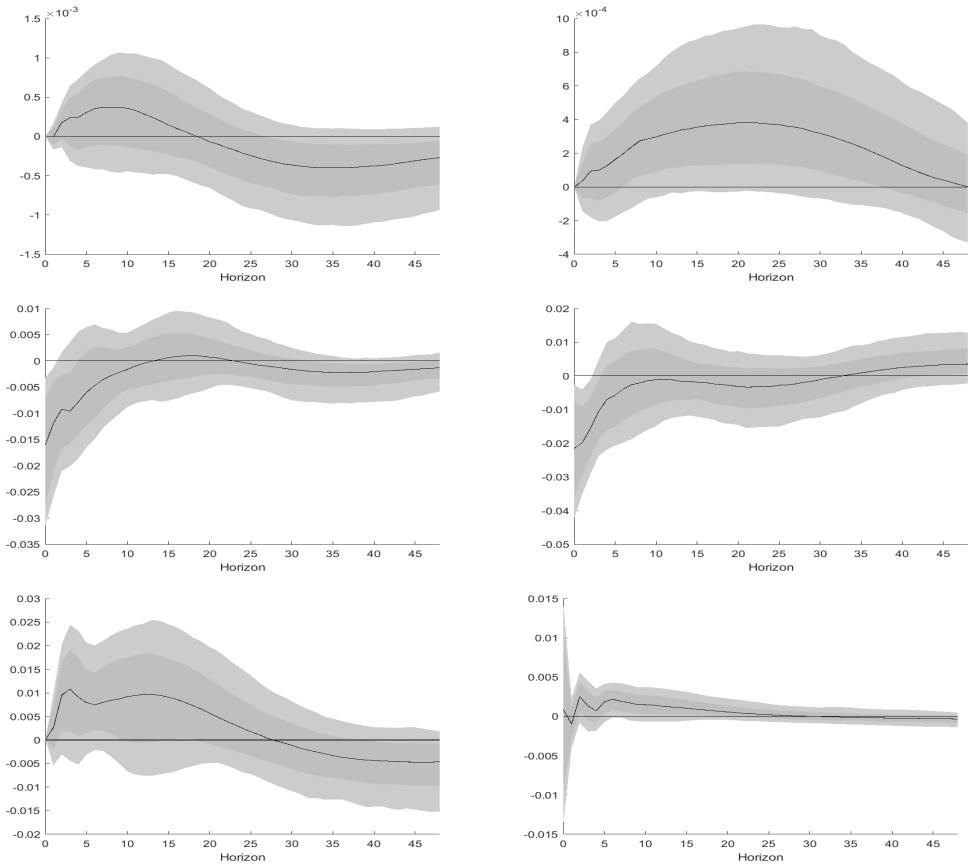

Figure 7: The impact of a balance sheet shock excluding ECB total assets on small firms. The order of the variables from left to right, top to bottom is GDP, CPI, CISS, EONIA-MRO spread, MRO rate and the turnover of small firms. The impulse responses of GDP, CPI and MRO rate are restricted to being zero upon impact. The responses of financial stress and the EONIA-MRO spread are assumed non-positive. The sign restrictions are in place for two periods. The turnover of small firms is left unrestricted. The figures show median responses with the light and dark gray areas representing 90% and two thirds of the identified posterior distribution, respectively.

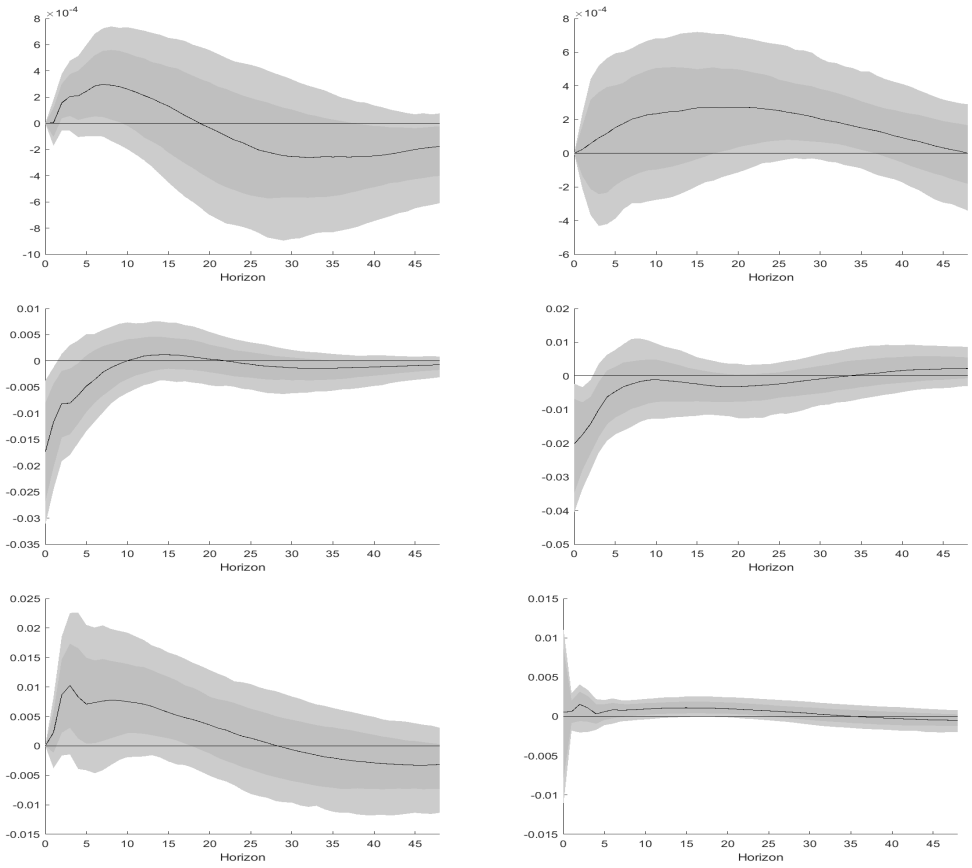

Figure 8: The impact of a balance sheet shock excluding ECB total assets on large firms. The order of the variables from left to right, top to bottom is GDP, CPI, CISS, EONIA-MRO spread, MRO rate and the turnover of large firms. The impulse responses of GDP, CPI and MRO rate are restricted to being zero upon impact. The responses of financial stress and the EONIA-MRO spread are assumed non-positive. The sign restrictions are in place for two periods. The turnover of large firms is left unrestricted. The figures show median responses with the light and dark gray areas representing 90% and two thirds of the identified posterior distribution, respectively.

picture stays the same for the euro area variables with both approaches that take announcement effects into account.

The impulse responses of the turnovers of large and small firms also resemble those we saw with an announcement shock. The impact on small firms in figure 7 is virtually identical to the response in figure 5. Thus the peak impact is again between 0.1 and 0.4 percent. Interestingly, the response of turnover of large firms is then again insignificant directly after the shock. The spike on lag three is visible but much less pronounced than with the asset purchase announcement shock. This could be due to the inclusion (or rather, lack of exclusion) of the refinancing operations. The reasoning is that as they are targeted in expanding lending to SMEs, including them dampens the clearly visible impact of the asset purchases.

It is further worth noting that the positive impact on large firms between, say, periods 10 and 22 is significant also with the refinancing operations included. Therefore large firms respond to the two measures differently only upon impact. This suggests that there are two separate responses; one related to the announcement of the measure and another, more sluggish one. It is likely that there are different transmission channels of monetary policy at play behind the dual response. We discuss this when concluding. To summarize, it seems that announcement effects contribute significantly to the transmission of unconventional monetary policy targeted at expanding the ECB's balance sheet. The impact is visible on both the euro wide variables as well as on the turnover of firms of different size in Finland. It further seems that the responses to refinancing operations and asset purchases are symmetrical for small firms, but not for large.

5.4 Easing the zero restrictions

We'll next see how easing the zero constraint on GDP and prices affects the responses to an unconventional monetary policy shock. For this exercise we chose the approach of identifying a shock to the balance sheet excluding ECB total assets, as that takes care of the announcement effects while including the targeted longer-term refinancing operations. The discussion for easing

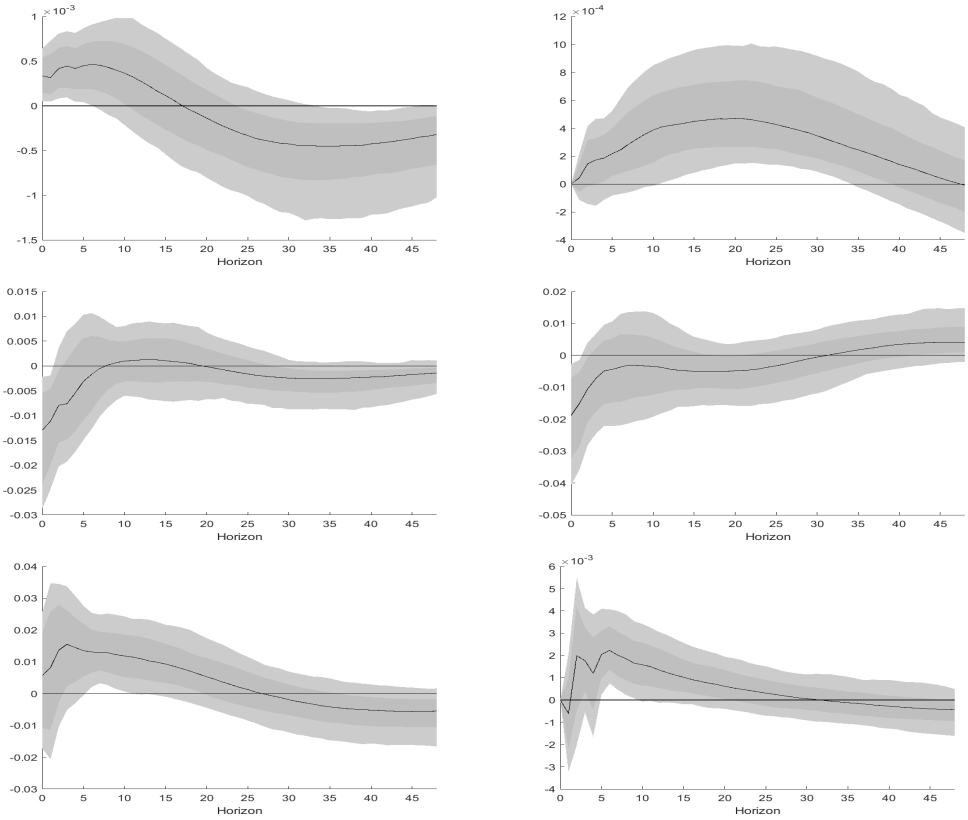

Figure 9: The impact of a balance sheet shock identified without ECB total assets (when GDP is restricted non-negative) on small firms. The order of the variables from left to right, top to bottom is GDP, CPI, CISS, EONIA-MRO spread, MRO rate and the turnover of small firms. The impulse responses of CPI and MRO rate are restricted to being zero upon impact. The response of GDP is assumed non-negative. Conversely, the responses of financial stress and the EONIA-MRO spread are assumed non-positive. The sign restrictions are in place for two periods. The turnover of small firms is left unrestricted. The figures show median responses with the light and dark gray areas representing 90% and two thirds of the identified posterior distribution, respectively.

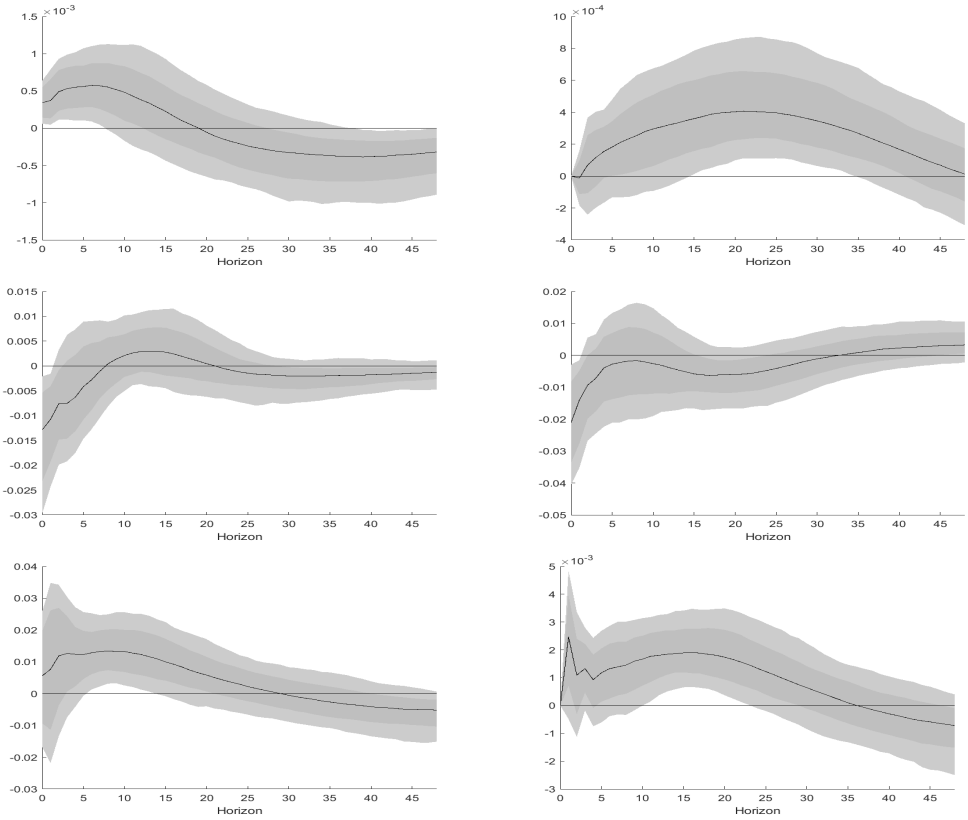

Figure 10: The impact of a balance sheet shock identified without ECB total assets (when GDP is restricted non-negative) on large firms. The order of the variables from left to right, top to bottom is GDP, CPI, CISS, EONIA-MRO spread, MRO rate and the turnover of large firms. The impulse responses of CPI and MRO rate are restricted to being zero upon impact. The response of GDP is assumed non-negative. Conversely, the responses of financial stress and the EONIA-MRO spread are assumed non-positive. The sign restrictions are in place for two periods. The turnover of large firms is left unrestricted. The figures show median responses with the light and dark gray areas representing 90% and two thirds of the identified posterior distribution, respectively.

the zero restrictions on the real variables can be found in section 4.3. We begin by allowing GDP to be positive but continue to restrict the impact on prices to zero, in line with Puonti (2019). The results can be seen in figures 9 and 10. All of the responses are significant even when considering the light gray area of 90% of the posterior mass. The identification seems tighter when the zero restriction on GDP is eased.

As anticipated, the response of GDP peaks slightly earlier at around seven months after the shock as a result to easing of the zero constraint. The positive impact is significant for some 12 months and finally fades out to trend around the 20 period mark. The impact is on the other hand slightly more sluggish than Puonti (2019) found when studying the exact time period used by Boeckx et al. (2017). The response turns negative after 20 periods, but unlike in Puonti (2019), the negative impact is significant as well. The response of euro area prices stays fairly similar to the responses found with other specifications, it only peaks slightly higher and is significant for a longer period. The responses of the financial variables likewise stay the same as in the other approaches including anticipation effects.

The results for small firms can be seen in figure 9. At a first glance it is evident that compared to other specifications, there is much less noise in the response at the first period after the shock. Consequently, the scale of the figure is different, even though the size of the impact is roughly the same. The spike at lag three is not as pronounced and the response peaks later, that is seven periods after the shock, being between 0.12 and 0.32%. Therefore the peak impulse response of small firms is slightly lower, but highly significant. The positive impact is furthermore significant for altogether some 12 periods before fading.

Interestingly, the impulse response of large firms in figure 10 resembles that found in response to an announcement shock rather than balance sheet shock excluding ECB total assets. Thus the hypothesis about the inclusion of the refinancing operations muffling the response of large firms seems to be reversed here. The impact on large firms in figure 8 was not due to the targeted longer-term refinancing operations, but rather timing. The impact on large firms peaks earlier than before at two months after the shock, where

it is between 0.07 and 0.4 percent. The positive impact peaks again around 17 months after the shock, where the median response is a little under 0.2%. The response finally fades 35 months after the innovation.

The response of large firms is thus both stronger and more persistent than with other approaches. Large firms additionally outperform smaller firms in response to the innovation, which contradicts the results from other approaches. As the responses of the euro area variables are also more significant, we have to consider the possibility that figures 9 and 10 represent the responses to several shocks at once. Boeckx et al. (2017) separate shocks to the real economy from the balance sheet shock by assuming both that the balance sheet shock does not instantaneously impact the real variables and that real shocks do not affect ECB's balance sheet. As we have eased the zero restriction on GDP and excluded ECB's total assets from our model, we are no longer assured that we are able to disentangle the two shocks.

To see whether misidentification is driving the better performance of large firms, we compare the results in figures 9 and 10 to responses to an asset purchase announcement shock, whilst easing the zero restriction on GDP. Similarly to before, we assume that real shocks do not impact the European Central Bank's announced asset purchases, because the ECB does not have exact knowledge about the present state of the economy. This enables us to credibly disentangle the two shocks once more. The responses to a announcement shock can be seen in figures 11 and 12. The response of large firms is fairly similar in both approaches, but the comparison of the size groups changes as the spike for small firms at lag three is bigger. The response of small firms is similar to what was seen before easing the zero restriction, with both the announcement and the balance sheet shocks. Therefore it could well be that figures 9 and 10 represent responses to more than one shock. Before discussing our final results, we however consider the exercise of easing the zero constraint on prices as well.

We additionally eased the zero restrictions on both real variables in accordance with the discussion in Uhlig (2017) and in section 4.3. The responses were fairly similar. The impact on GDP was however positive for a mere moment before turning significantly negative, which we find to be an im-

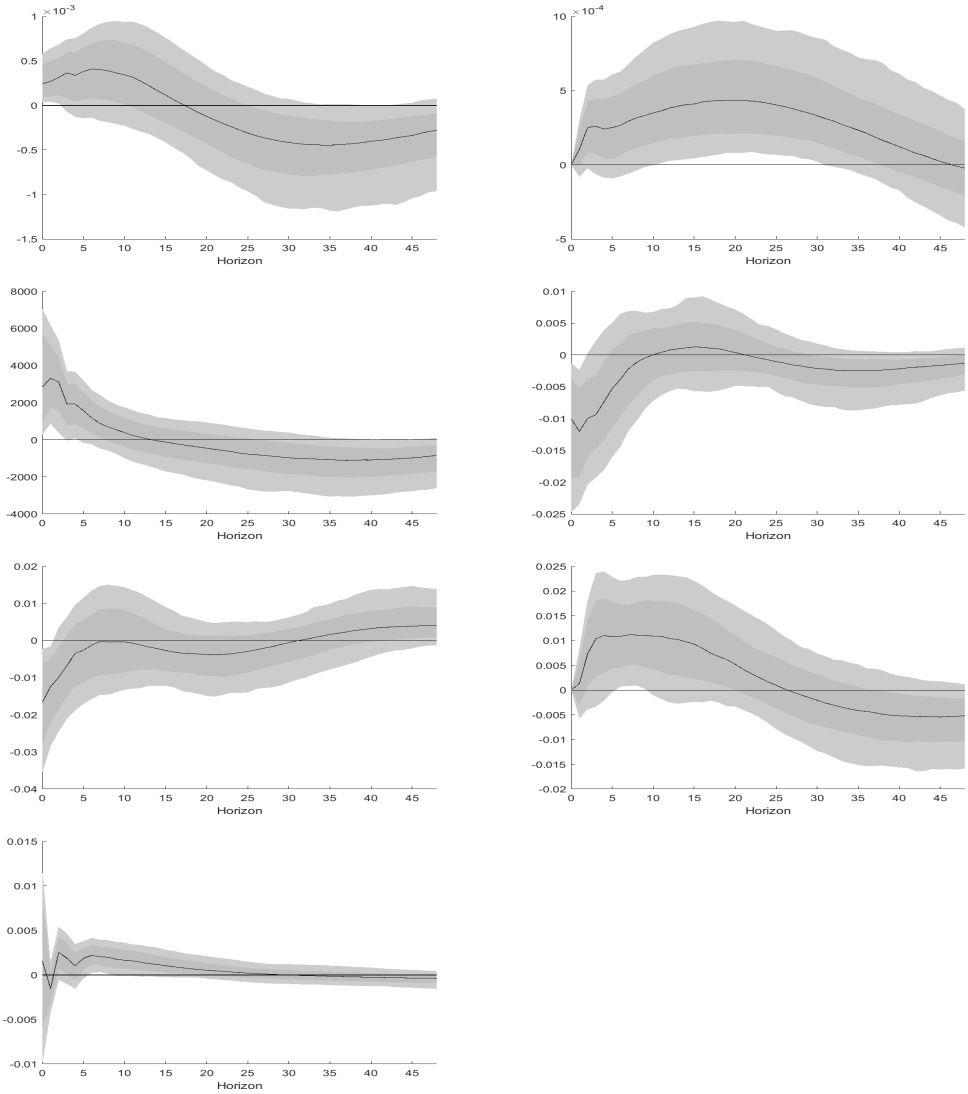

Figure 11: The impact of an asset purchase announcement shock (when GDP is restricted non-negative) on small firms. The order of the variables from left to right, top to bottom is GDP, CPI, ECB's announced purchases, CISS, EONIA-MRO spread, MRO rate and the turnover of small firms. The impulse responses of CPI and MRO rate are restricted to being zero upon impact. The responses of GDP and announced purchases are assumed non-negative. Conversely, the responses of financial stress and the EONIA-MRO spread are assumed non-positive. The sign restrictions are in place for two periods. The turnover of small firms is left unrestricted. The figures show median responses with the light and dark gray areas representing 90% and two thirds of the identified posterior distribution, respectively.

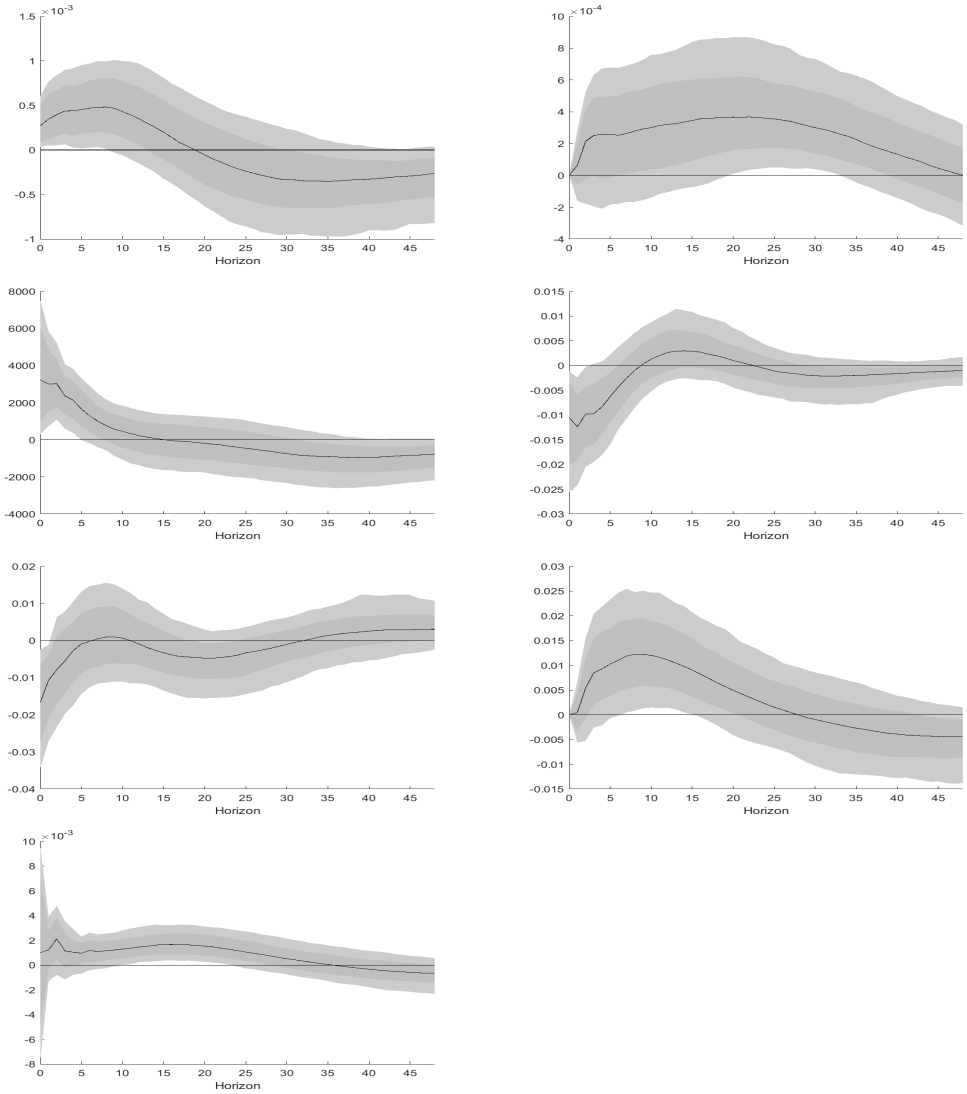

Figure 12: The impact of an asset purchase announcement shock (when GDP is restricted non-negative) on large firms. The order of the variables from left to right, top to bottom is GDP, CPI, ECB's announced purchases, CISS, EONIA-MRO spread, MRO rate and the turnover of large firms. The impulse responses of CPI and MRO rate are restricted to being zero upon impact. The response of GDP and announced purchases are assumed non-negative. Conversely, the responses of financial stress and the EONIA-MRO spread are assumed non-positive. The sign restrictions are in place for two periods. The turnover of large firms is left unrestricted. The figures show median responses with the light and dark gray areas representing 90% and two thirds of the identified posterior distribution, respectively.

plausibly adverse reaction. Therefore we assume that the zero restriction upon impact on euro area consumer prices is sensible and leave the results unpublished.

5.5 Discussion

We have identified an unconventional monetary policy shock affecting the central bank's balance sheet in three different ways; through the size of the balance sheet, based on announced asset purchases and through the impact of a balance sheet expansion on the rest of the variables in our model. The baseline specification in line with Boeckx et al. (2017) did not catch anticipation effects that manifested as spikes in the responses of the turnovers of Finnish firms a few moths after the shock. The two other approaches were successful in catching the early responses of firms.

We found the approach in fashion of Hesse et al. (2018) most appealing on paper, as it takes the anticipation effects into account and further does not discriminate between policy measures. Therefore, for robustness, we considered the analysis of Puonti (2019) and eased the zero restriction on GDP in the identification of a balance sheet shock, excluding ECB total assets. The identification turned out to be sharper when the GDP was restricted non-negative. There is however a possibility that the easing of the zero restriction on GDP causes the model to be misidentified and therefore we repeated the exercise with the asset purchase announcement shock in line with, for example, Weale and Wieladek (2016). The comparison between the turnovers of large and small firms changed quite significantly and thus we base our conclusions on the results from both the identification in line with Hesse et al. (2018) and Weale and Wieladek (2016), but with the response of GDP eased only with the latter.

The response to a balance sheet shock excluding ECB total assets peaks higher for small firms but is more persistent for large when the zero restriction on GDP is in place. In case of an announcement shock, the overall impact on small firms is higher and also more persistent. When the zero restriction on GDP is eased, the peak impact of small firms is still higher, but the response

is less persistent than that of large firms.[19] Therefore the impact on small firms peaks higher with all specifications, but on average, the response is more persistent when it comes to the turnover of large firms.

We are thus unable to conclude that small firms would disproportionately benefit from monetary policy measures targeted at expanding the balance sheet of the central bank. The impact of the unconventional measures is asymmetrical, but the difference is in favor of small firms in the first 10 or so periods after the shock, and of large firms after that. Thus, the differences somewhat cancel each other out in the long run.

Therefore it is also safe to say that unconventional monetary policy is not driving the revisions of the Trend Indicator of Output, which sparked our interest in the topic in the first place. If it were, the revisions would have fluctuated above and below zero based on how much time had passed since the the last unconventional monetary policy innovation. The reason why small firms have outperformed large in Finland, and therefore the explanation of the revisions of the trend indicator, remains a mystery.

Our conclusion is in contrast with the seminal result of Gertler and Gilchrist (1994), at least if we believe that the results found in response to an expansionary shock should be a mirror image to the period of credit crunch the original paper focused on. Then again, the result in Gertler and Gilchrist (1994) was that the impact of a monetary policy tightening depends on the phase of the business cycle. Therefore it might be that the expansionary monetary measures in 2010–2018 did not benefit small firms in Finland disproportionately due to the fact that, for the most part, the economy was not in an acute economic slump.

It was also the hypothesis of Hesse et al. (2018), that the impact of unconventional monetary policy diminishes as the economy is no longer in severe economic distress. The results by Hesse et al. (2018) show that early asset purchases had a significant effect on the real variables in the US and UK, but that the more recent purchases have not been as efficient. Our results point at the same direction. The responses of the real variables in

[19]It should be noted that the results for large and small firms are from different models, which introduces some uncertainty into our comparisons.

the baseline model in line with Boeckx et al. (2017) were significantly less pronounced than in the original paper. The same is true for the results building on the approach of Hesse et al. (2018). Therefore the aggregate impact of the European Central Bank's balance sheet policies seems to have weakened over time. The results by Boeckx et al. (2017) and Hesse et al. (2018) however did not consider the impact of the policies on firms and thus we have no point of comparison for our results concerning the asymmetry of the responses of large and small firms.

The pattern of the impact on firms is interesting. Introducing announcement effects to the baseline model revealed a short but strong positive impact a couple of months after the shock. As the impact occurs shortly after the innovation, the spike-shaped response is likely due to the signalling channel of monetary policy.[20] It could for example be that the measures taken by the European Central Bank increased expected inflation, which boosted consumption and thus increased the turnover of Finnish firms. This response is of similar magnitude for both size groups, which is as expected in case of increased demand. There is however another, more sluggish wave of response to monetary policy measures by both the turnovers of large and small firms. With most specifications, the later response is bigger for small firms, but more persistent for large. The shape differs slightly between the two groups. For large firms there is a gradual build-up to the second peak, whereas the turnover of small firms peak for the second time shortly after the first spike.

Our hypothesis was that the unconventional measures eased the access to credit for small firms through the banking sector. We further expected this impact to favor small firms over large, as we assume that the large firms weren't credit constrained to begin with. Based on a quick glance, it seems that the eased access to credit has had a significant impact, but for both large and small firms. We are however unable to distinguish between different transmission channels based on shock analysis alone. It might well be, for example, that the policy measures taken in the euro zone have depreciated the euro, which again has boosted exports. Large firms might be more export-

[20]See section 3.3 for an overview of the transmission channels of (un)conventional monetary policy.

driven and thus benefit more from the exchange rate channel. To summarize, we have established the impact of unconventional monetary policy measures targeted at expanding the ECB's balance sheet on the turnover of Finnish firms aggregated by size. Event studies with qualitative micro data are more suitable for determining exactly how monetary policy transmits to the firm level. This work is left for future research.

6 Conclusions

In this thesis we investigate the impact of unconventional monetary policy targeted at expanding the balance sheet of the European Central Bank on Finnish firms. More specifically, we look for asymmetries between the responses of large and small firms to the asset purchase programme and targeted longer-term refinancing operations. We are additionally interested in finding out whether the expansionary monetary policy in the euro zone that has prevailed for most of the decade has created bias in timely statistics that typically rest on data collected from large firms.

Our interest was sparked by the fact that the earliest estimate of the state of the economy provided by the statistical authorities in Finland, namely the Trend Indicator of Output, has on average underestimated the month-on-month change during the time the monetary policy has been loose. That is, the growth rate of the economy has consistently been revised upwards after data from small firms has become available for nearly six years and counting. Our hypothesis is consequently that small firms have benefited from balance sheet policies more than large, up to the point where it is visible in the data.

We compare the impact on two turnover series; the first one being the sales inquiry data for large firms the TIO builds on and the other one a monthly series for the aggregated turnover of firms that are considered small by EU standards. By using the the sales inquiry data we are able to simultaneously look for asymmetries between size groups as well as to directly see whether there is potential for bias in the TIO.

We study the impact of the ECB's balance sheet policies on turnovers of the heterogeneous firms using a vector autoregressive model in line with

Boeckx et al. (2017). In the baseline model a structural balance sheet shock is identified such that it is expected to increase the size of the European Central Bank's balance sheet and decrease financial stress as well as the EONIA-MRO spread. The responses of GDP, consumer prices and the main refinancing operations rate are assumed zero upon impact. The turnovers of large and small firms enter the model separate and their responses are left unrestricted.

We augment the analysis with several alterations to the aforementioned baseline model with the aim of catching the timing of the responses better. Our alternative approaches of identifying a balance sheet shock based on the rest of the variables in the model in spirit of Hesse et al. (2018) and a asset purchase announcement shock building on Weale and Wieladek (2016) caught earlier responses than the baseline model. The identification is further sharpened by the easing of the zero constraint of GDP, as suggested by Puonti (2019). Therefore we base our conclusions on results from the altered versions of the model.

The impact on both small and large firms is positive and unfolds in two stages; upon impact and again significantly later. We find asymmetry in the responses of firms of different size. On average, small firms peak higher and earlier, whereas the response of large firms persists for longer. The balance sheet policies benefit small firms more within 12 months of the shock, after which the impact on large firms is more significant. Therefore we are unable to conclude that the unconventional monetary policy measures would have benefited small firms disproportionately. Then again we find evidence, on the one hand, that the balance sheet policies have affected the turnover of firms in Finland through more than one monetary policy transmission channel. On the other hand, our results suggest that the impact of the European Central Bank's unconventional monetary policy measures has diminished since the analysis of Boeckx et al. (2017).

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